STATE OF NEW YORK

DEPARTMENT OF CONSERVATION

WATER POWER AND CONTROL COMMISSION

THE GROUND-WATER RESOURCES OF FULTON COUNTY, NEW YORK

By

THEODORE ARNOW

Geologist, U. S. Geological Survey

Prepared by the

U. S. GEOLOGICAL SURVEY IN COOPERATION WITH THE WATER POWER AND CONTROL COMMISSION

BULLETIN GW-24

ALBANY, N. Y.

1951

STATE OF NEW YORK
DEPARTMENT OF CONSERVATION
WATER POWER AND CONTROL COMMISSION

PERRY B. DURYEA.....*Conservation Commissioner, Chairman*
B. D. TALLAMY.....*Superintendent of Public Works*
NATHANIEL GOLDSTEIN.....*Attorney General*
JOHN C. THOMPSON, *Executive Engineer*

UNITED STATES DEPARTMENT OF THE INTERIOR

OSCAR L. CHAPMAN, *Secretary*

GEOLOGICAL SURVEY

WILLIAM E. WRATHER.....*Director*
C. G. PAULSEN.....*Chief Hydraulic Engineer*
A. N. SAYRE.....*Chief, Ground Water Branch*
M. L. BRASHEARS, JR.....*District Geologist*

CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope of investigation	2
Methods of investigation	2
Acknowledgments	2
Geography	4
Location and culture	4
Topography and drainage	4
Climate	5
Geology and water-bearing properties of the formations	6
Geologic history	6
Rock formations	16
Pre-Cambrian rocks	16
Grenville series	16
Igneous rocks	16
Cambrian formations	16
Potsdam sandstone	16
Theresa dolomite	16
Little Falls dolomite	16
Ordovician formations	16
Tribes Hill limestone	16
Lowville limestone	16
Amsterdam limestone	17
Glens Falls limestone	17
Canajoharie shale	17
Quaternary deposits	17
Glacial deposits	17
Alluvial deposits	17
Ground water	18
Source	18
Occurrence	18
Pre-Cambrian rocks	18
Cambrian formations	19
Potsdam sandstone and Theresa dolomite	19
Little Falls dolomite	19
Ordovician formations	19
Limestones	19
Canajoharie shale	19
Quaternary deposits	19
Glacial deposits	19
Alluvial deposits	20

CONTENTS — (Continued)

	Page
Recovery	20
Dug wells	20
Drilled wells	20
Springs	21
Utilization	23
Quality	24
Chemical constituents and physical properties	24
Dissolved solids	24
Iron (Fe)	24
Manganese (Mn)	24
Chloride (Cl)	24
Sulfate (SO_4)	27
Hardness	27
Bicarbonate (HCO_3)	27
Hydrogen-ion concentration (pH)	27
Temperature	27
Relation of water quality to rock type	28
Pre-Cambrian rocks	28
Potsdam sandstone	28
Theresa dolomite	28
Little Falls dolomite	28
Ordovician limestones	28
Canajoharie shale	28
Glacial deposits	28
Alluvial deposits	28
Summary of ground-water conditions	29
References	30
Index	41

ILLUSTRATIONS

			Page
Plate	1.	Map of Fulton County, N. Y., showing wells and springs	(back)
	2.	Geologic map of Fulton County, N. Y.	(back)
Figure	1.	Index map of New York showing coverage of cooperative ground-water studies	3
	2.	Cross section of faults in the Mohawk Valley in Fulton and Montgomery Counties	9
	3.	The supposed preglacial valley of the Sacandaga River	10
	4.	Electrical resistivity data, lines 1, 3, and 9, Gloversville area, Fulton County, N. Y.	11
	5.	Electrical resistivity data, lines 2 and 6, Gloversville area, Fulton County, N. Y.	12
	6.	Electrical resistivity data, line 4, Gloversville area, Fulton County, N. Y.	13
	7.	Electrical resistivity data, lines 5, 7, and 8, Gloversville area, Fulton County, N. Y.	14
	8.	Time-distance graph of seismic refraction data, Gloversville area, Fulton County, N. Y.	15
	9.	Areal distribution of dissolved solids and total hardness in well and spring waters in Fulton County, N. Y.	26

TABLES

		Page
1.	Geologic formations in Fulton County, N. Y., and their water-bearing properties	7
2.	Approximate area of intake openings of open-end casings, perforated casings, and well screens	21
3.	Records of selected springs in Fulton County, N. Y.	22
4.	Chemical analyses of natural waters from Fulton County, N. Y.	25
5.	Selected well logs from Fulton County, N. Y.	31
6.	Records of selected wells in Fulton County, N. Y.	33
7.	Reports dealing with ground-water conditions in New York published by the New York State Water Power and Control Commission	40

GROUND-WATER RESOURCES OF FULTON COUNTY, N. Y.

By THEODORE ARNOW

ABSTRACT

This report was prepared as part of a State-wide survey of the ground-water resources of New York being made by the United States Geological Survey in cooperation with the New York Water Power and Control Commission. Most of the field work was done during 1946, but some additional work was done during the succeeding four years. Records were obtained for 219 wells and springs, and 22 water samples were collected for chemical analysis.

Fulton County is in the east-central part of the State of New York. The northern half of Fulton County lies in the southernmost extension of the Adirondack Mountains and the southern half lies in the north-central part of the Mohawk Valley. Most of the population and industry is concentrated in the southern flat-lying area. The northern area constitutes part of the Adirondack Forest Preserve and is sparsely populated. Manufacturing is the chief means of livelihood, and the main industry is glovemaking. Drainage in Fulton County is divided into south-flowing streams tributary to the Mohawk River and northeast-flowing streams entering the Sacandaga River or the Sacandaga Reservoir, which covers a large area in the northeastern part of the County. The climate is temperate. The mean annual temperature is 45° F., and the average annual precipitation is 44 inches.

The geologic structure of Fulton County is characterized by at least 10 major normal faults which are part of the great Mohawk Valley fault series. The bedrocks range from pre-Cambrian to Ordovician in age, and in most areas they are mantled by unconsolidated Pleistocene glacial deposits or Recent alluvial deposits.

Precipitation within the County is the source of essentially all ground water in Fulton County. Glacial deposits constitute the major aquifers and the water is recovered from these beds mainly by means of dug wells and springs. Where glacial deposits are thin or otherwise unproductive, water is recovered from the bedrock by means of drilled wells. The glacial deposits, however, are the only potential source of large supplies of ground water. Geophysical exploration east of Gloversville indicates the existence of a buried preglacial valley of the Sacandaga River.

Ground water is used in Fulton County chiefly for domestic and farm purposes and the small supply of water obtained from dug wells generally is satisfactory. Industrial development is primarily in the urban areas, and water used for manufacturing processes is obtained from municipal water systems, which, in two out of seven communities, supply ground water. The quality of the ground water in Fulton County in general is good, and there are few reports of waters having a high mineral content or being excessively hard.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

This report covering Fulton County is part of a survey being made by the United States Geological Survey in cooperation with the New York Water Power and Control Commission to provide information concerning the source, quantity, quality, and related aspects of the ground-water resources of New York. The areas in the State in which ground-water studies have been completed and in which work is now in progress are shown in figure 1. Reports have been published on the ground-water conditions of the Binghamton and Cortland areas, and Albany, Montgomery, Rensselaer, and Schoharie Counties. (See table 7.) Reports are presently being prepared for Columbia, Greene, Saratoga, Schenectady, Washington, Wayne, Seneca, Delaware, Ontario, and Dutchess Counties.

METHODS OF INVESTIGATION

Most of the field work for this report was done in 1946 by members of the Geological Survey, Ground Water Branch, but additional work, primarily of a geophysical nature, was done during the succeeding years. Records were obtained for 219 wells and springs, and 22 water samples were collected for chemical analysis. Part of the time was spent in the study of the glacial deposits and rock formations that are the immediate source of the ground water.

The locations of all wells and springs for which records are given are shown on plate 1. It has not been possible to check the exact location of some of the sites in the field, and the locations of such wells or springs are based on information given by the driller, owner, or other persons.

The wells, in general, have been numbered in order from west to east, beginning with Fu 1. The springs have been numbered in a separate series beginning with number Fu 1Sp. Although the prefix "Fu" signifies that the particular well or spring is in Fulton County, its use was considered unnecessary on plate 1, as the plate covers only Fulton County.

As an aid in reporting a well or spring location anywhere in New York State, meridian lines at 15-minute intervals have been lettered consecutively from west to east, beginning with "A" and ending with "Z". Similarly, parallels of latitude have been numbered at 15-minute intervals from north to south, beginning with "1" and ending with "17". The intersections of the coordinates form points from which, by means of distance and direction, the wells and springs can be accurately located. For example, well Fu 18 (8U, 4.9S, 3.0E) is 4.9 miles south and 3.0 miles east of the intersection of lines 8 and U. The coordinates, distances, and directions for each well and spring are shown in the location column in the tables of well and spring records.

ACKNOWLEDGMENTS

This report was prepared under the supervision of M. L. Brashears, Jr., District Geologist for the U. S. Geological Survey in New York and New England. The office of the New York State Geologist and officials of the New York State Science Service generously supplied information and publications that were of great help in interpreting the geology of the area. Appreciation is also expressed to the members of the New York State Health Department in the central offices at Albany and the regional office at Johnstown who provided information and assistance. Among the other State agencies contributing much information were the Department of Commerce and the Water Power and Control Commission. The State Science Service and the Department of Public Works contributed personnel and equipment for the geophysical studies in the County. Thanks are offered to the many well owners, well drillers, engineers, and municipal officials who provided information necessary for this report. Water samples and well and spring records were collected by Mr. V. H. Rockefeller, and the water samples were analyzed at the laboratories of the New York State Health Department or the U. S. Geological Survey, Quality of Water Branch, Washington, D. C. The illustrations were prepared by Mrs. Helen A. Miller.

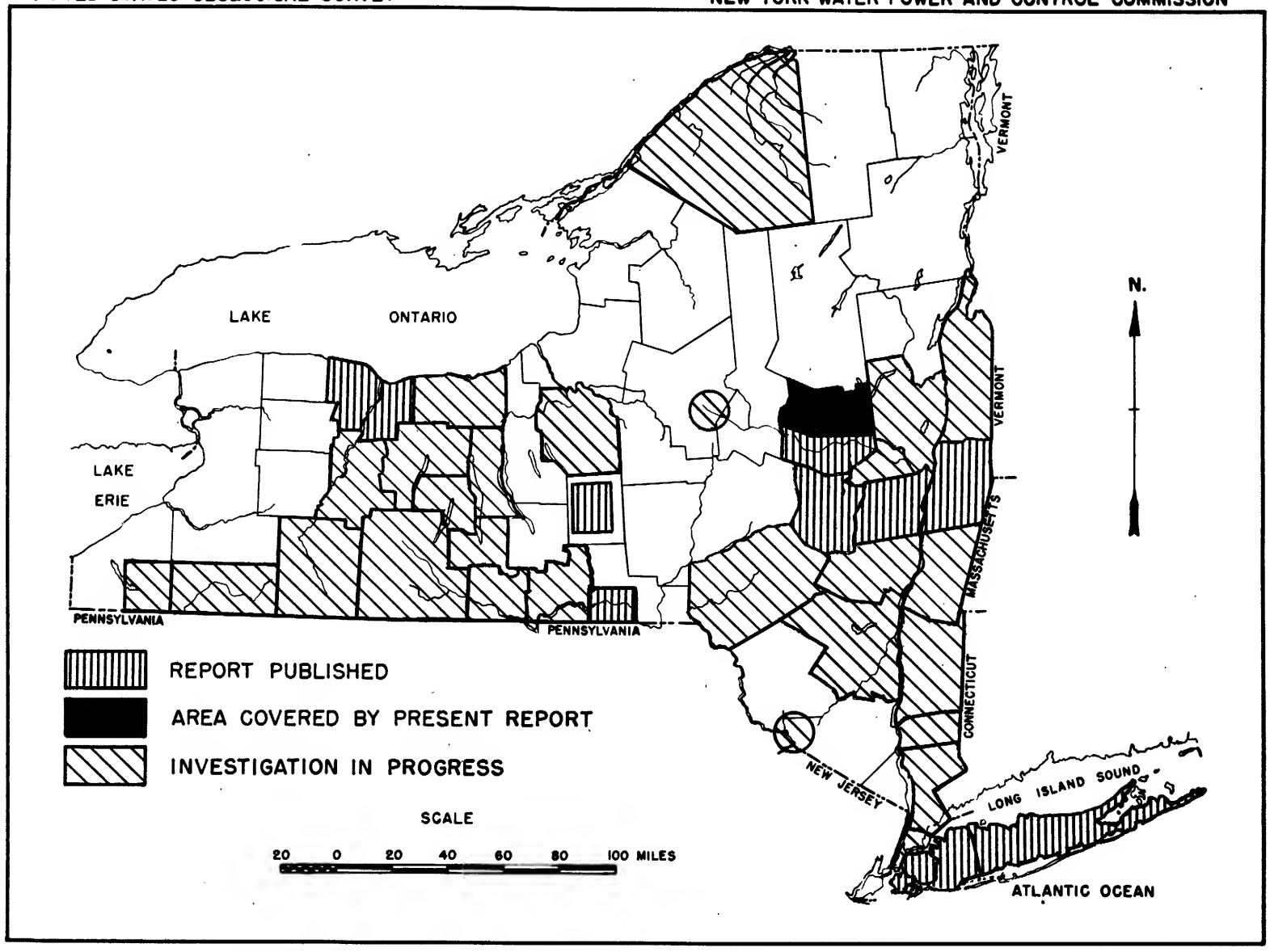


Figure 1.—Index map of New York showing coverage of cooperative ground-water studies.

GEOGRAPHY

LOCATION AND CULTURE

Fulton County has an area of 497 square miles and lies in the southernmost part of the Adirondack Mountains and the north-central part of the Mohawk Valley. According to the 1950 census, the population of the County was 51,061, giving an average density of 103 persons per square mile compared to 297 for the State as a whole. The County boasts only two communities with a population over 1,500. These are Gloversville, having a population of 24,274, and Johnstown, the County seat, having 10,914 people. The urban portion, therefore, comprises about 70 percent of the total population of the County.

In 1945 there were 1,017 farms in the County covering 163 square miles, or about 33 percent of the total area. These farms were valued at about $4,989,300, and a total of 1,575 people were engaged producing crops, livestock, and dairy products valued at $1,816,070.

In 1947, 326 manufacturing establishments employed 9,742 people who produced products valued at $37,506,000, most of which may be attributed to the glove industry. Fulton County normally produces more than 50 percent of the low-priced gloves and nearly all of the finer-quality gloves made in the United States. Glovemaking began in the County before the Revolutionary War and is still concentrated in the area. The craft does not require much power or local raw materials but depends primarily upon the individual skill of the worker, which has passed from generation to generation. This has attracted and monopolized other similarly skilled workers.

Large quantities of lumber were formerly obtained from the northern part of the County, but owing to depletion of the natural stock and the creation of large State reservations, the importance of the lumber industry has gradually decreased. It is now cheaper to import western lumber than it is to use the native product. Counterbalancing the decline of the lumber industry has been the rise of the summer-resort trade. The creation of the Sacandaga Reservoir and the existence of numerous lakes and mountains has provided an attractive background for many camp sites, hotels, and recreation areas. Entry to the region is provided by several modern highways and the Fonda, Johnstown, & Gloversville railroad.

TOPOGRAPHY AND DRAINAGE

Fulton County presents a series of contrasts in drainage and topography. It is practically cut in two by the watershed divide that separates the drainage area of the south-flowing Mohawk River and the drainage area of the northeast-flowing Sacandaga. This divide runs in a westerly direction across the County south of Broadalbin and Vail Mills, swings north of Gloversville, and passes in a northwesterly direction through the mountainous lake country that forms the northern part of the County (pl. 1). A peculiar situation is presented by the Sacandaga River which flows in a general southerly direction toward the Mohawk River, and for no apparent topographic reason, reverses its course at Northampton, and flows north to join the Hudson River drainage system. This phenomenon will be more fully discussed later in the report. The Sacandaga River, Kennyetto Creek, Mayfield Creek, and West Stony Creek are the principal northeast-flowing streams. The principal streams flowing south to the Mohawk River are the Cayadutta, Caroga, Zimmerman, Crum, and East Canada Creeks. The latter forms part of the western boundary of Fulton County. Records of flow for two streams in Fulton County have been collected by the Surface Water Branch of the U. S. Geological Survey. A stream-gaging station is maintained on East Canada Creek at East Creek and a record for the period since 1946 is available. A station was operated upstream, at Dolgeville, on East Canada Creek from 1928 to 1946. Another stream-gaging station was formerly maintained at Broadalbin on Kennyetto Creek; the period of record there is from 1939 to 1946. Records of stream flow are published in the annual water-supply papers of the U. S. Geological Survey. Current measurements are on file at the office of the Geological Survey, Surface Water Branch, Albany, N. Y.

The binary aspect of the topography of the County is due to the fact that the northern part is underlain by hard crystalline rocks of the Adirondack mass, whereas the southern part is underlain by the softer sedimentary rocks of the Mohawk Valley. Both areas are cut diagonally by a series of large faults. Two of these faults are particularly worthy of note. The Noses fault crosses the County line southwest of Johnstown, strikes northeastward, and leaves the County northwest of Northville. The upthrow, which is as much as 1,500 feet at the northern end, is on the west side of the fault. This side forms a great escarpment of crystalline rock rising above the lowlands of the Mohawk Valley. East of the Noses fault lies the Batchellerville fault, which is marked by

another escarpment of crystalline rock extending from Batchellerville, in Saratoga County, southward past Northampton, and then southeastward. The Batchellerville fault also has a displacement of about 1,500 feet but the upthrow side is to the east. The Sacandaga Reservoir and all the major communities of Fulton County lie on the plain of the great sunken block between the two crystalline masses. This sunken block, or graben, consists primarily of limestone and shale which, upon weathering, yield a soil superior to that found in the mountainous areas. This soil and the less rigorous climatic conditions of the lower altitudes, have made the lowland the dominant area of human activity in Fulton County.

One of the outstanding features of the lowland is the great Sacandaga Reservoir. This was created in 1930 by damming of the Sacandaga River at Conklingville. It covers 42 square miles and has a capacity of about 38 billion cubic feet. Its chief purpose is to eliminate seasonal fluctuations in the flow of the Hudson River.

The lakes in the mountainous area northwest of Gloversville are the only other large bodies of standing water in Fulton County. The lakes range in size from small ponds to areas of more than 1 square mile. Six of the lakes are more than a quarter of a square mile in area and two are more than 1 square mile in area. Most of the lakes were formed in valleys blocked by glacial drift (Brigham, 1929, p. 12).[1]

CLIMATE

According to records compiled by the U. S. Weather Bureau since 1892, the mean annual air temperature at Gloversville is 45° F. January and February are the coldest months. The average temperature during these months is 19° F., whereas during July, the warmest month, the average temperature is 69° F. The highest and lowest temperatures on record are 99° and −34° F., recorded in July 1936 and December 1917, respectively. Killing frosts have occurred as late as June 4 and as early as September 10; more commonly, in late April or early May, and late September or early October.

The mean annual precipitation is about 44 inches. The greatest annual precipitation on record, 56.62 inches, was recorded in 1898, and the least, 29.30 inches, was recorded in 1930. The rainfall is fairly evenly distributed throughout the year, but the heaviest precipitation is during June, July, August, and September, the months of the growing season.

The average annual snowfall is about 84 inches, and the observed extremes range from 119 inches, in 1915, to 51 inches, in 1919. Most of the snow falls between October and April. Only occasional traces have been observed in September and May.

[1] See references listed alphabetically at the end of this report.

GEOLOGY AND WATER-BEARING PROPERTIES OF THE FORMATIONS

Most of Fulton County lies within the boundaries shown on three U. S. Geological Survey topographic maps, the Broadalbin, Gloversville, and Lasselsville quadrangles. The remaining area is shown on the Canajoharie, Fonda, Amsterdam, Little Falls, and Stony Creek quadrangles. The geology of the Broadalbin and Little Falls quadrangles has been published in detail (Miller, 1911; Cushing, 1905) and the Broadalbin report has been used as a basis for many of the stratigraphic data given in this report. The stratigraphic column for Fulton County is shown in table 1 and the bedrock geology is shown on plate 2.

GEOLOGIC HISTORY

The recorded geologic history of Fulton County begins in pre-Cambrian time when the area was covered by ocean waters. The Grenville series, consisting of several thousand feet of sand, shale, and limestone was deposited in the sea. After deposition of the sediments, igneous activity began on a major scale, and large bodies of syenite and granite were intruded into the Grenville. During or after the period of igneous activity the region was subjected to great forces, which resulted in the metamorphism of both the igneous and sedimentary rocks and the consequent formation of gneiss and schist. Because of later diastrophism the beds now dip at angles ranging from vertical to nearly horizontal. The dip, however, generally is about 25° toward the south.

The next noteworthy geologic event was the elevation of the entire region above sea level and the commencement of a long period of erosion. Minor igneous activity resulted in the intrusion of a series of fine-grained gabbro and diabase dikes into the older rocks. Erosion continued and at the dawn of the Paleozoic era, a fairly flat surface existed approximately at sea level.

Early in the Cambrian period the ocean encroached upon the land again and deposition of Paleozoic sediments began. The sea invaded the Mohawk Valley from the east and did not reach Fulton County until Upper Cambrian time, when the Potsdam sandstone was deposited. The Potsdam was followed by the series of alternating sandstone and dolomite that comprises the Theresa dolomite; and finally, was followed by the Little Falls dolomite. Owing to the irregularity of the old depositional surface and the uneven rise of the Paleozoic seas, the Theresa or Little Falls was deposited directly on the pre-Cambrian surface in certain localities. After deposition of the Little Falls dolomite the land once again was elevated above sea level and subjected to erosion. This marked the end of the Cambrian period and the resultant unconformity separates the beds of the Cambrian and Ordovician systems.

Then followed an oscillation of the land surface. The Tribes Hill limestone was deposited in a shallow sea and during the ensuing period of erosion was nearly or completely removed from Fulton County.

After erosion of the Tribes Hill limestone, the Lowville and Amsterdam limestones, commonly called the Black River beds, were deposited. The Black River beds are thin in Fulton County and are separated from the overlying Glens Falls limestone by a slight disconformity, thus indicating that a period of uplift and erosion separated the deposition of the two (Megathlin, 1938, p. 91). After the Glens Falls limestone was deposited, an influx of fine muddy sediment resulted in the deposition of the Canajoharie shale. This is the youngest consolidated sedimentary formation now present in Fulton County. Although no post-Canajoharie sedimentary rocks are present in the area, it is believed that deposition continued through the Silurian (Miller, 1929, p. 59) and possibly into the Devonian (Goldring, 1931, p. 367). This opinion is based on outcrops of Silurian and Devonian strata south of Fulton County, which if projected, would extend as far north as the southern slopes of the Adirondacks.

The dip of the Paleozoic rocks ranges from southeast to southwest and from horizontal to 6°. In general, however, the dip is about 2° toward the southwest. Locally the shales dip as much as 50°; but the steep dips are always associated with faults and result from the dragging action involved in the faulting.

During the Appalachian Revolution at the close of the Paleozoic era the region was uplifted. It is believed that at this time the bedrock was sheared by the series of north-trending faults which have so greatly influenced the present-day topography. The faults are nearly all vertical and in the majority of places the upthrow is on the west side. In addition to the Noses and Batchellerville faults previously described, at least eight major faults are present in Fulton County. The general relationships of these faults are shown on figure 2 and plate 2. It is interesting to note that the

Table 1.—Geologic formations in Fulton County, N. Y., and their water-bearing properties

Age	Geologic formation	Maximum thickness (feet)	Character of material	Water-bearing properties
Recent	Alluvium	?	Stratified clay, silt, sand, and gravel beds associated with the larger streams.	Good aquifer but limited in areal extent. Chemical characteristics of water similar to those of surface water.
Pleistocene	Glacial drift	265+	Till, heterogeneous mixture ranging in size from clay to boulders. Grades into stratified material in some places. Outwash, ranges from clay to gravel, well sorted. Occurs as lenses within the nonstratified material, or as independent deposits.	Most extensively used aquifer in Fulton County. Supplies water mostly to shallow dug wells. Average yield less than 3 gallons per minute. May yield large supplies of water to drilled wells. Average yield of wells reported is 10 gallons per minute, but this figure would be substantially increased if modern drilling techniques were employed. Chemical character of waters in glacial drift varies greatly and is dependent upon local conditions.
Ordovician	Canajoharie shale	100+	Dark-gray to black fine-grained compact thin-bedded and even bedded shale; rather calcareous, particularly toward base.	Most extensively used bedrock aquifer in Fulton County. Yields range from 2 to 22 gallons per minute but average about 5 gallons per minute. Water is hard and is reported to contain hydrogen sulfide.
	Glens Falls limestone	20+	Dark thin-bedded irregular compact limestone with distinct shale partings; very fossiliferous.	Moderately important aquifer. Average yield is 5 gallons per minute. Chemical character of water variable.
	Amsterdam limestone	10+	Pure massive blue-gray to gray-black crystalline limestone; fossiliferous.	Unimportant aquifer. Record for only one well obtained.
	Lowville limestone	20−	Fine-grained light dove-colored limestone, filled with dark vertical columnar fucoidal stems which give a bird's-eye appearance.	Unimportant aquifer. Record for only one well obtained.
	Tribes Hill limestone	Very few feet, if present at all.	Thin-bedded, blue-gray fucoidal sandy limestone.	Unimportant aquifer. No well records obtained.
Cambrian	Little Falls dolomite	200+	Fine-grained pale bluish-gray crystalline dolomitic limestone. Contains numerous chert beds and nodules of crystalline calcite.	Important source of water. Yields of 2 to 40 gallons per minute reported. Average yield is 9 gallons per minute. Water moderately hard and fairly low in total dissolved solids.
	Theresa dolomite	150±	Alternating beds of pure gray fine-grained sandstone, and bluish-gray fine-grained dolomitic limestone.	Unimportant aquifer. Record for only one well obtained.
	Potsdam sandstone	40+	Light-colored vitreous sandstone with a few calcareous layers in the upper part and conglomeratic beds at the base. Massive or thin-bedded. Contains prominent ripple marks.	Unimportant aquifer. Record for only one well obtained.
Pre-Cambrian	Igneous rocks (undifferentiated)	?	Syenite porphyry and granite porphyry, metamorphosed and gneissoid in character. Contains pegmatite, diabase, and gabbro dikes.	Moderately important aquifers. Yield unpredictable, ranging from practically zero to 20 gallons per minute. Water generally soft and low in dissolved solids.
	Grenville series	10,000±	Metamorphosed sediments—gneisses, schists, and quartzites. Many different facies showing extreme variations in mineralogy.	

famous mineral waters at Saratoga Springs rise to the surface along the Saratoga fault, the easternmost of the Mohawk fault series.

After the Appalachian Revolution, continued erosion eventually reduced the land surface of the region to a low-lying peneplain. At the close of Mesozoic time, during the Laramide Revolution, the land was raised approximately to its present level.

The most recent event of major geologic importance in the region was the great Pleistocene ice invasion. There were several periods of glaciation, (Miller, 1924, p. 91; MacClintock and Apfel, 1944), but in Fulton County the last ice sheet overrode and removed the sediments laid down by earlier glaciers. The main ice sheet originated in Labrador and spread across Canada into the United States. The ice moved along the east side of the Adirondack mass down the Champlain and Hudson Valleys, and a branch lobe extended westward into the Mohawk Valley covering Fulton County. The ice eventually retreated but left behind a great mass of deposits in the form of drumlins, moraines, kames, and other stratified water-laid material. This huge drift body caused a major reversal in the direction of flow of the Sacandaga River. Prior to glaciation this stream flowed in a southerly direction and emptied directly into the Mohawk River. After the retreat of the glacier or during one of the interglacial stages, however, the old channel of the Sacandaga was blocked by debris south of Northampton; therefore, the river reversed its course and flowed northeast through the channel of a formerly southwest-flowing tributary (Miller, 1924, p. 112). The divide at Conklingville was breached, and the Sacandaga joined the Hudson River at Luzerne. Kennyetto Creek, which bends abruptly at Vail Mills, was similarly affected, and before the creation of the Sacandaga Reservoir it flowed northeast to converge with the Sacandaga River at Northampton.

The preglacial path of the Sacandaga River south of Northampton has long been a subject of academic debate. Brigham (1929, pp. 55-57) suggested that the preglacial Sacandaga River followed the present axis of the Sacandaga Reservoir and then flowed in a southwesterly direction, paralleling the Noses fault line, reaching the Mohawk through the plain west of Fonda, in Montgomery County. It is interesting to note, therefore, that data obtained for this report indicate part of the buried channel and appear to confirm Brigham's postulate. East of Gloversville bedrock altitudes drop from 790 to less than 675 feet above sea level in the short distance (8/10 mile) between Fu 173 and Fu 90, and the thickness of overburden at Fu 90 is known to be at least 265 feet (fig. 3).

The existence of a major buried valley close to a populated area is of considerable importance because of the possibility of obtaining large quantities of ground water from such valleys. With this in mind, an attempt was made to collect additional well records that would help to delineate the valley. This proved almost fruitless because of the lack of deep wells in the area. Therefore, electrical resistivity depth profiles were obtained at nine sites (fig. 3) by using the Gish-Rooney type of apparatus. Seismic profiles were also obtained at two of the same sites to compare with the resistivity determinations.[2] The data obtained by the geophysical studies are given in figures 4, 5, 6, 7, and 8.

Preliminary interpretations of the geophysical data indicate that at resistivity site 4, seismic site 1, the thickness of overburden is at least 200 feet. Thus the maximum altitude of bedrock is 740 feet. When compared with the altitude of bedrock in well Fu 179, 810 feet, this suggests that the buried channel lies at or just north of resistivity site 4. At resistivity site 6 the interpretations indicate that the thickness of overburden is about 170 feet; therefore, the altitude of bedrock is about 650 feet. This would seem to indicate that the buried valley lies beneath site 6. On figure 3 that part of the buried valley that has been located by well and geophysical data is shown by a solid line. That part of the valley where lack of bedrock information prevents its accurate location is shown by a dashed line. Only part of the total number of wells and rock outcrops used in defining the buried valley are shown on figure 3.

Till probably fills most of that part of the buried valley shown by the solid line. However, more permeable deposits of sand and gravel are present in the buried valley within the city limits near the eastern boundary of Gloversville. Most of the material filling other parts of the buried valley also is probably till.

[2] The resistivity profiles were obtained by Mr. Philip Donnerstag of the New York State Science Service. The seismic profiles were obtained by Mr. Paul Bird and his assistant, Mr. Burt Renzetti, of the Bureau of Soil Mechanics of the New York State Department of Public Works. State-owned refraction equipment was used.

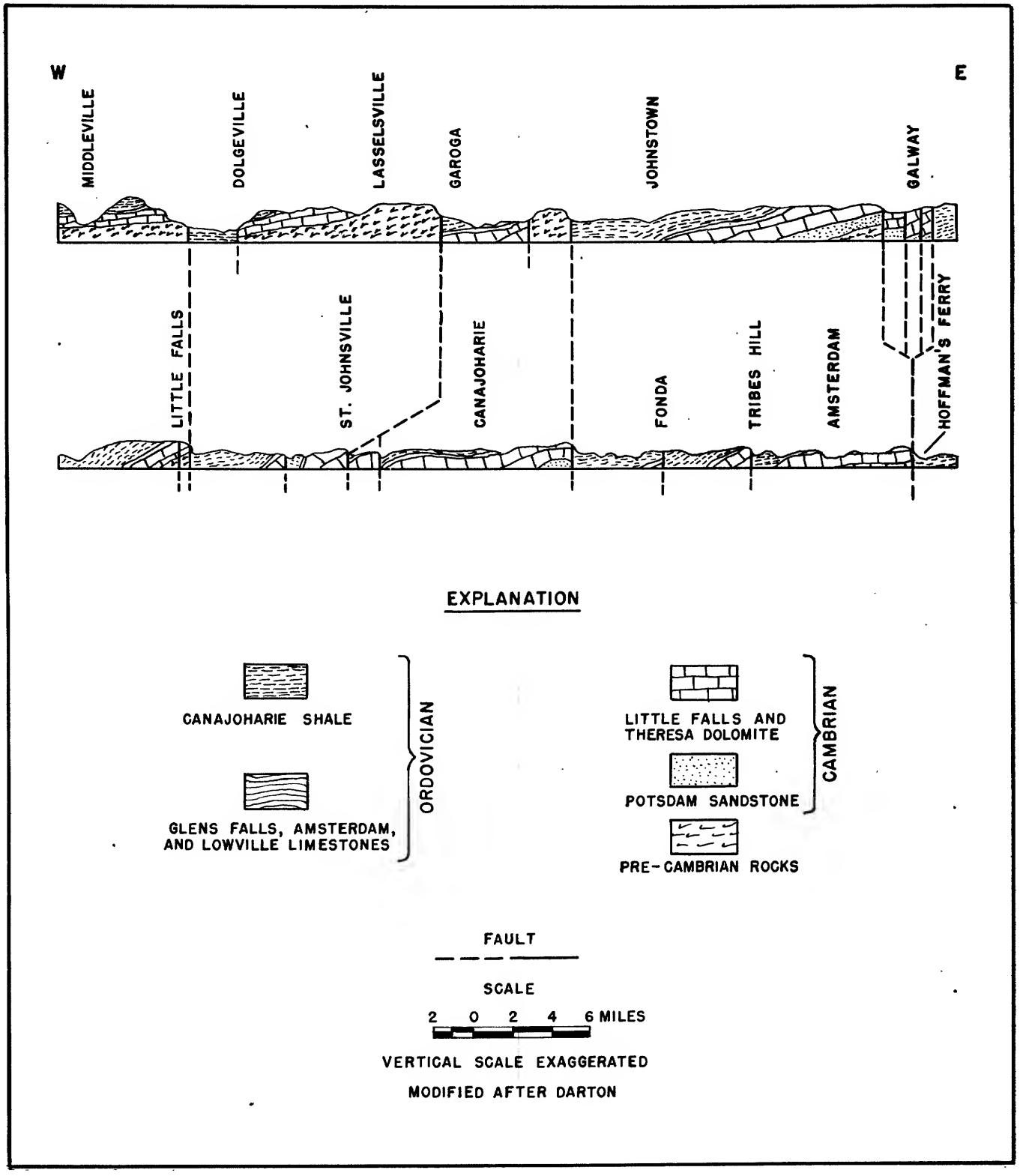


Figure 2.—Cross section of faults in the Mohawk Valley, in Fulton and Montgomery Counties.

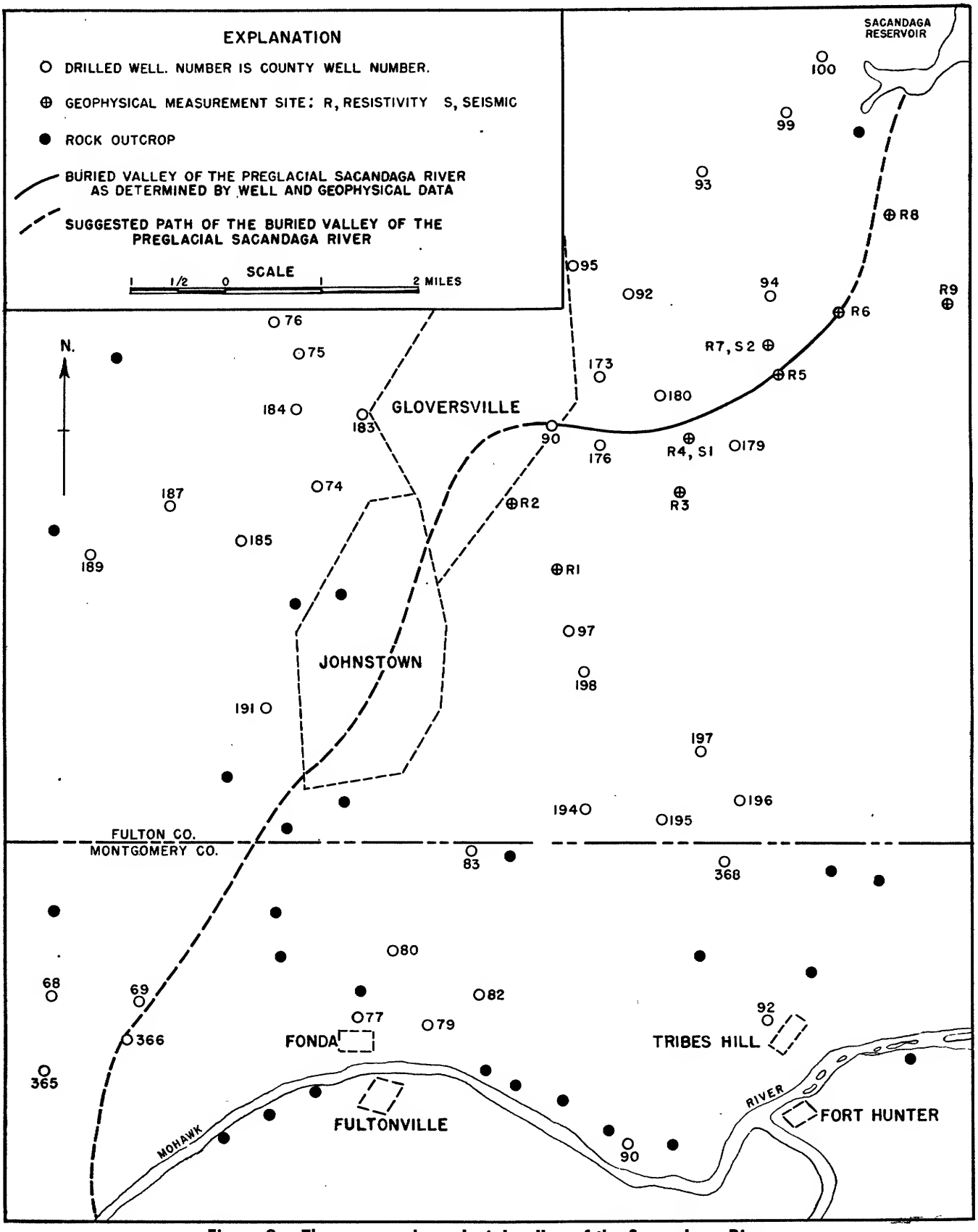
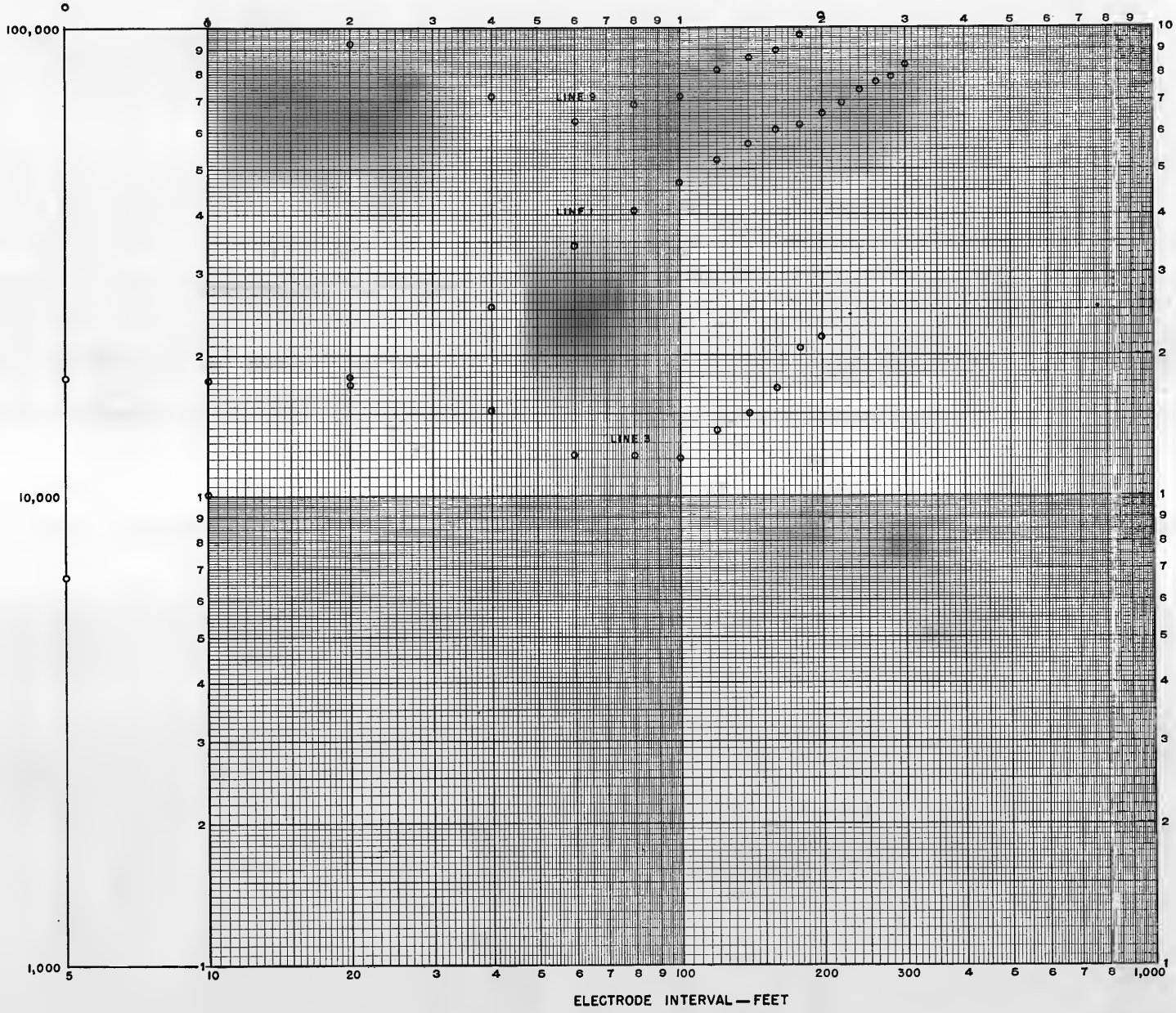


Figure 3.—The supposed preglacial valley of the Sacandaga River.



LINE R-1, FULTON CO., OCT. 18, 1949
LOCATION: 8 V, 15.5 S., 8.5 E.
BEARING: N. 9° E.
ALTITUDE: 719 FEET

LINE R-3, FULTON CO., OCT. 19, 1949
LOCATION: 8 V, 12.9 S., 12.4 E.
BEARING: N. 66° W.
ALTITUDE: 840 FEET

LINE R-9, FULTON CO., OCT. 21, 1949
LOCATION: 8 V, 12.9 S., 12.4 E.
BEARING: N. 3° W.
ALTITUDE: 841 FEET

Figure 4.—Electrical resistivity data, lines 1, 3 and 9, Gloversville area, Fulton County, New York.

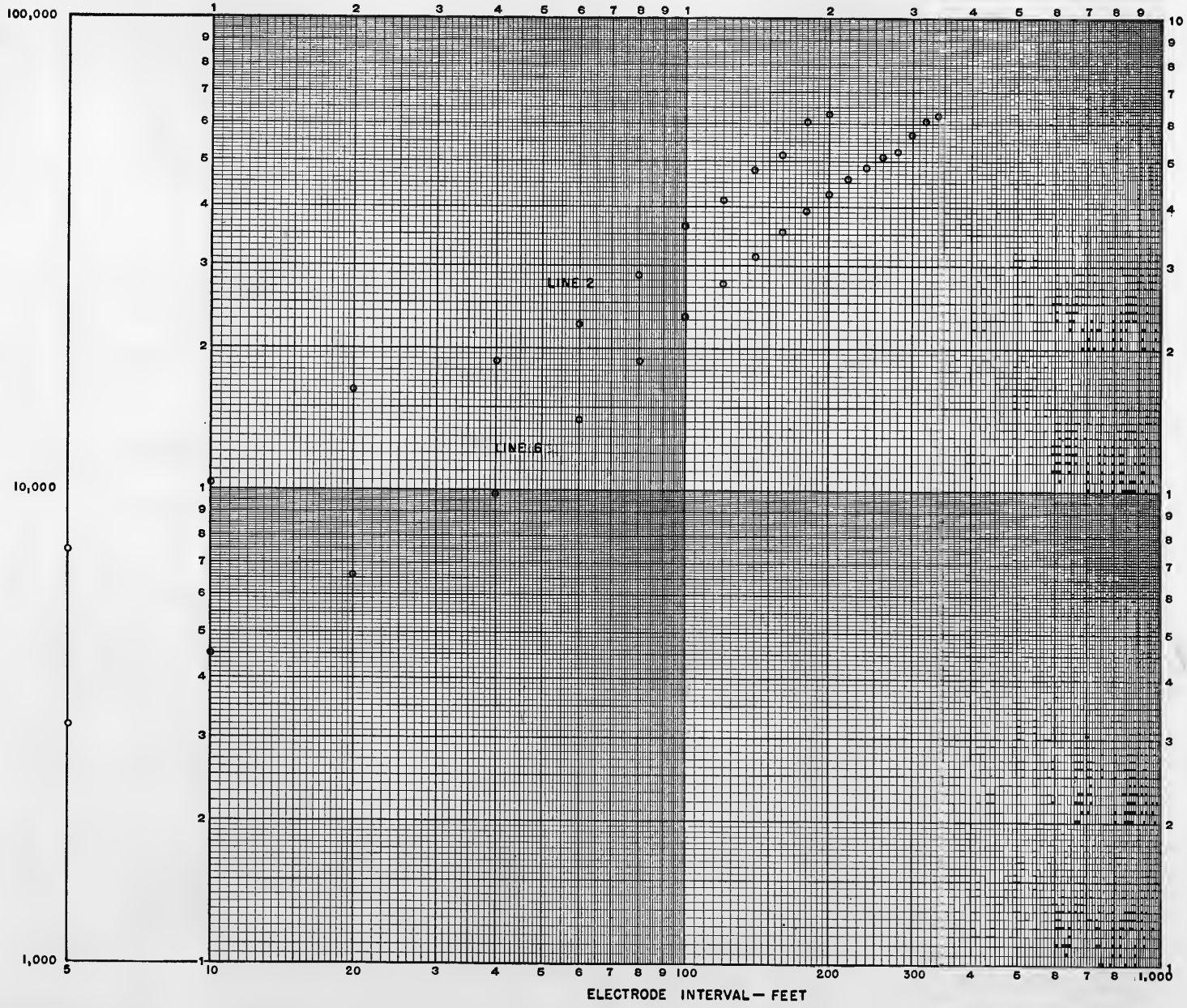


Figure 5.—Electrical resistivity data, lines 2 and 6, Gloversville area, Fulton County, New York.

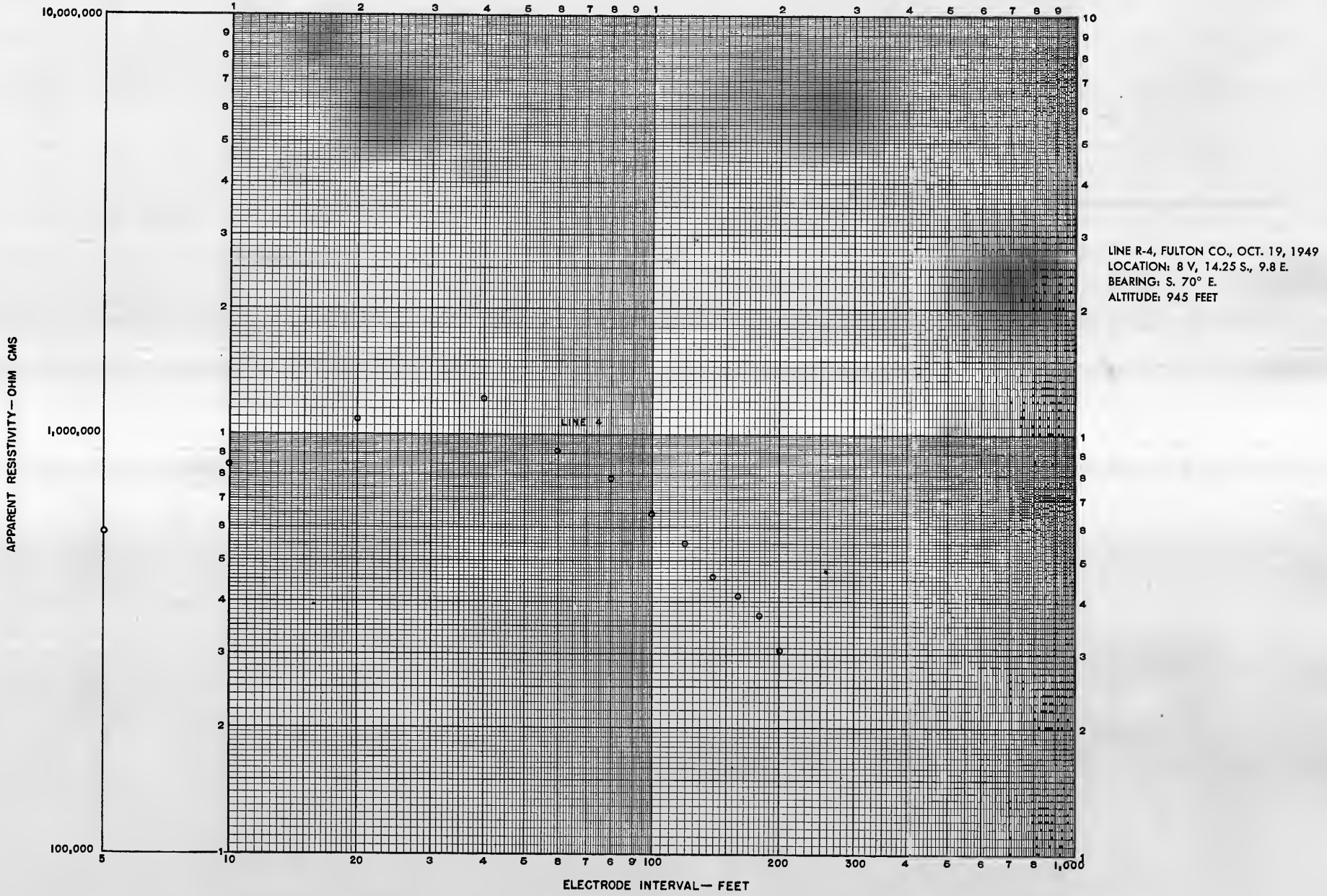


Figure 6.—Electrical resistivity data, line 4, Gloversville area, Fulton County, New York.

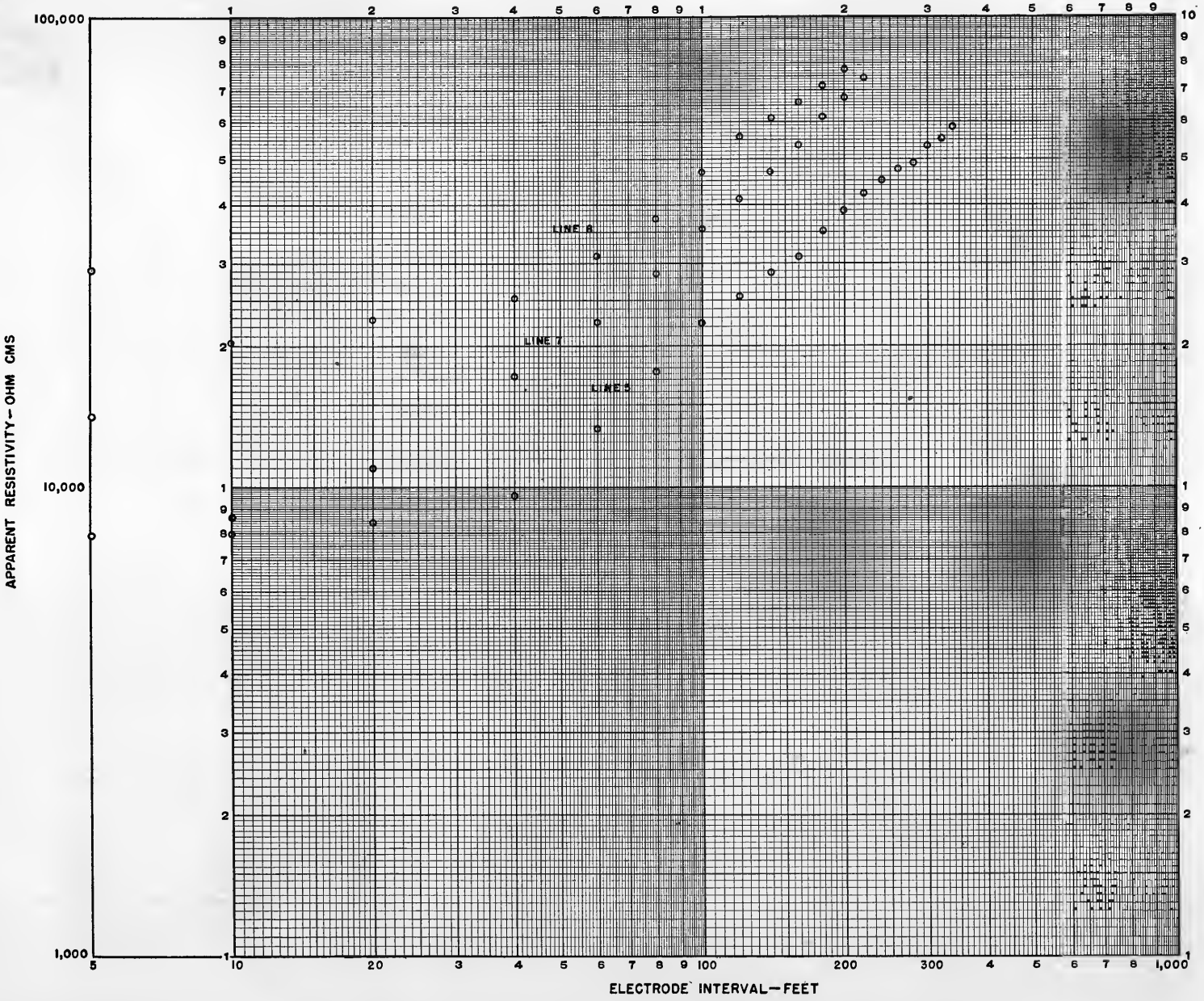


Figure 7.—Electrical resistivity data, lines 5, 7 and 8, Gloversville area, Fulton County, New York.

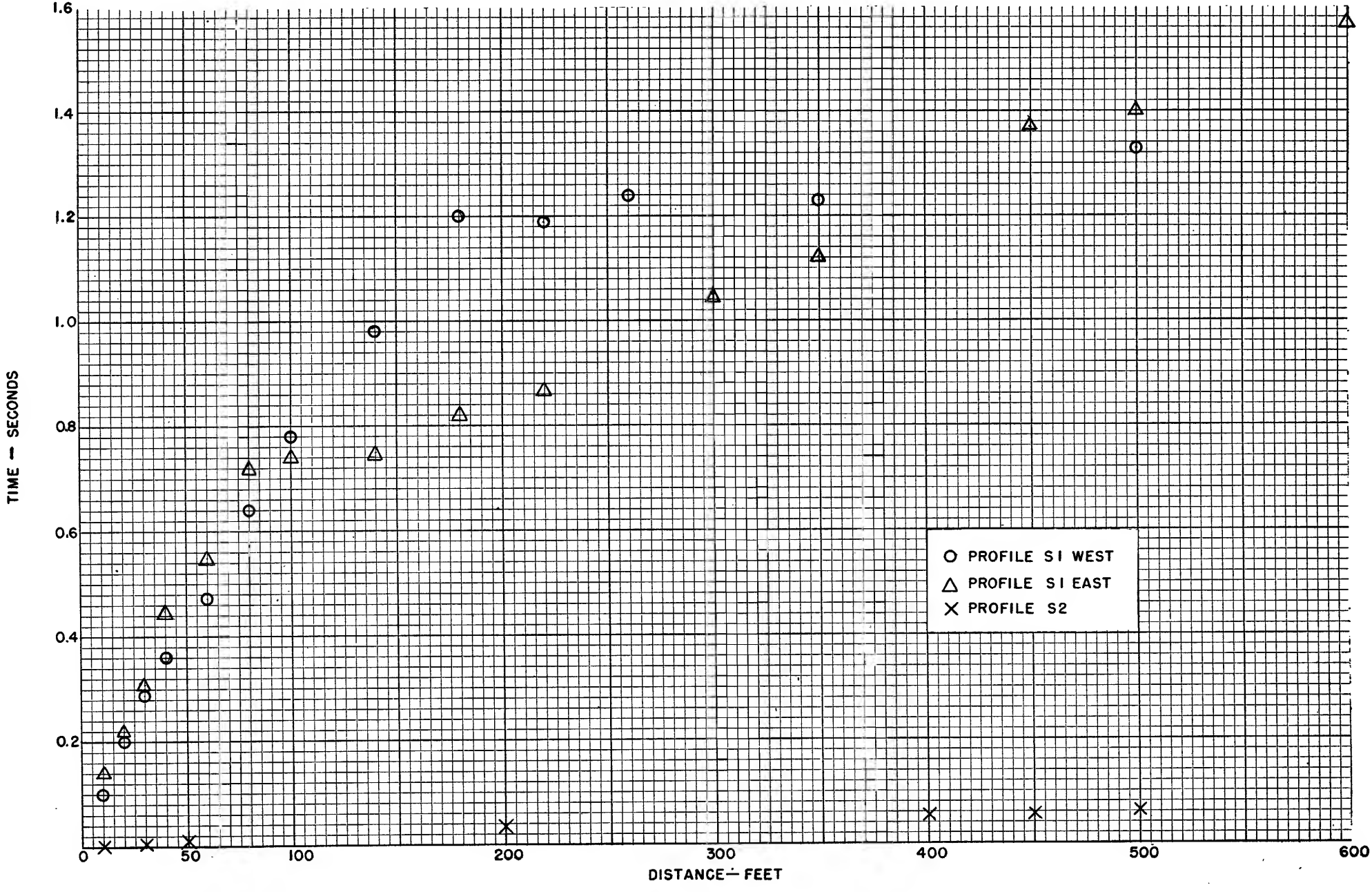


Figure 8.—Time-distance graph of seismic refraction data, Gloversville area, Fulton County, New York.

ROCK FORMATIONS

Pre-Cambrian rocks

The bedrock floor of about 60 percent of Fulton County consists of pre-Cambrian rocks (pl. 2). Numerous springs flow from the pre-Cambrian rocks, and the rocks yield moderate supplies of ground water to drilled wells.

The pre-Cambrian rocks generally have little indication of bedding or other stratification but are broken by a great number of intersecting joints. These joints are irregular and are in several series that practically box the compass. Cushing (1905, p. 49), however, found two major sets of joints.

Grenville series.—The Grenville series is one of the oldest groups of rocks on earth. Originally deposited in a shallow marine sea as limestone, sand, and shale, it has since been subjected to so intense metamorphism that the resulting rocks are almost too numerous to classify. Miller (1911, p. 8) describes nine major varieties in the Broadalbin quadrangle and states that it would be hopeless to attempt to describe all the others. One of the more prevalent rocks is a coarse-grained light-brown to white almost pure quartzite. There are several varieties of schist, and many of gneiss, the most predominant rock of all. The gneiss ranges from fine- to coarse-grained and from white to almost metallic black. It varies greatly in composition and the gneissic bands are thin to extremely wide.

Igneous rocks.—Granite porphyry and syenite porphyry are the predominant igneous rocks in the region. Much of the syenite porphyry is medium-grained, greenish or light gray, whereas the granite porphyry is gray to pinkish gray. Both rocks are distinctly gneissoid and in many places so intimately associated with the Grenville series that the contact is gradational. The texture and structure of the Grenville series and the associated pre-Cambrian igneous rocks are also quite similar; therefore, in this report they are considered as a single aquifer and on plate 2 are mapped as a unit.

Cambrian formations

Potsdam sandstone.—Where present in Fulton County the Potsdam sandstone directly overlies the pre-Cambrian rocks (pl. 2). The Potsdam is a dense light-colored vitreous sandstone which has a few calcareous beds near the top and some conglomeratic layers at the base. It may be either massive or thin-bedded. In Fulton County the Potsdam sandstone is present in only a small area and its maximum thickness is only 40 feet. Therefore, and because of its impervious nature, it is unimportant as a source of ground water.

Theresa dolomite.—The Theresa dolomite is transitional between the Potsdam sandstone and the overlying Little Falls dolomite. The Theresa consists of alternating beds of pure gray fine-grained sandstone, and bluish-gray fine-grained dolomitic limestone. The upper and lower contacts of the Theresa are gradational, and Miller (1911, p. 31), believes that the maximum thickness of the dolomite in Fulton County is about 150 feet. The Theresa dolomite underlies only a small area in the eastern part of the County and is of little importance as a source of ground water.

Little Falls dolomite.—The Little Falls dolomite is one of the most widespread of the Paleozoic formations in the Mohawk Valley. In most places it is a massive fine-grained bluish-gray dolomite but includes a few sandy or cherty beds. The maximum thickness in Fulton County is about 200 feet. Because of its resistance to erosion it forms prominent cliffs and is much quarried. The dolomite has a series of irregular joints that are less evident than those of the pre-Cambrian rocks. Because it underlies the heavily populated part of the County where many wells have been drilled, the dolomite is one of the more important aquifers in the County.

Ordovician formations

Tribes Hill limestone.—The Tribes Hill limestone is not definitely known to be present in Fulton County. It is not discussed further in this report.

Lowville limestone.—The Lowville limestone is a massive fine-grained light dove-colored pure limestone that characteristically weathers to a light ash-gray color. In many places it has a "bird's-eye" appearance caused by the occurrence of many dark cylindrical deposits, the ends of which are scattered over the bedding planes. These deposits were formerly thought to be fossil coral, but now are considered to be worm tubes filled with calcite. The Lowville in most places is less than 20 feet thick and is unimportant as a source of ground water.

Amsterdam limestone.—The Amsterdam limestone is a massive pure blue-gray to gray-black fossiliferous crystalline limestone. In Fulton County the limestone rarely exceeds a thickness of 10 feet and consequently is of little value as a source of ground water.

Glens Falls limestone.—The Glens Falls limestone is a dark-gray irregularly and thin-bedded limestone, having distinct shale partings. It has so rich an abundance of fossils that the limestone is known locally as the "shell-rock". In Fulton County the Glens Falls rarely is more than 20 feet thick. Owing to its limited areal extent and thickness the Glens Falls has been utilized as a source of ground water in only a few places in the County. Kay (1937) has published detailed descriptions of the subdivisions of this limestone.

Canajoharie shale.—The Canajoharie shale is the most widespread of the Paleozoic rocks in Fulton County. It underlies about a fifth of the County, chiefly in the south-central part, including nearly all of the Gloversville-Johnston plain. The Canajoharie is a fine-grained thin-bedded shale that is dark gray to black and in most places highly calcareous. In Fulton County the shale probably is more than 100 feet thick at its northernmost outcrop near the Noses fault line, and it thickens markedly toward the south. The shale has numerous tension joints that can transmit large quantities of ground water. For this reason and because of its areal extent and thickness the Canajoharie shale is the most important consolidated aquifer in Fulton County.

Quaternary deposits

Glacial deposits.—Glacial deposits differ considerably from one another in lithology and thickness. They completely mantle the entire region except for small isolated areas of rock outcrop and Recent alluvium. For this reason and because they are more permeable than the bedrock, the glacial deposits supply most of the ground water pumped in Fulton County.

The glacial deposits may be divided into till and outwash. Till is a heterogeneous mixture of largely unsorted material ranging in size from clay to boulders, and in Fulton County, exists primarily in the topographic forms of ground moraine and drumlins. Ground moraine is a relatively thin layer of till that is spread over a large area. It was deposited primarily at the base of the glacier. Almost the entire northern mountainous region, as well as large areas in the southern part of Fulton County, are covered by ground moraine. Owing to the lack of sorting and the presence of much fine material, the ground moraine possesses a low permeability factor and yields only small to moderate supplies of ground water. Overlying the ground moraine, particularly in the Johnstown-Gloversville area, are numerous smooth, oval-shaped hills. These hills, of clayey till and as much as 150 feet in height, and nearly a mile in length, are drumlins. Most of the drumlins are also poor sources of ground water.

Outwash consists of sorted materials that have been deposited directly by glacial streams, have been reworked by glacial streams from unsorted deposits, or have been deposited in glacial lakes. The lake deposits, mostly silt or clay, constitute poor aquifers because of their impermeable nature. The more permeable outwash deposits were laid down by streams emanating directly from the glaciers. As the streams varied in volume and velocity dependent upon the rate of melting of the ice, so do the deposits vary in character. They are generally cross-bedded and show marked gradations in size ranging from silt through coarse gravel. Outwash may be underlain, overlain, or intermingled with till deposits, and it may be impossible to draw sharp boundary lines between the two types of material.

Outwash deposits are present in many parts of Fulton County. A broad westward-trending belt of kames and kame terraces extends through the center of the County from the Saratoga border to the Noses fault line. The kame deposits are partly stratified and consequently yield ample water for household use to drilled wells. In other areas the outwash deposits are confined largely to the valleys, and the upland areas are mantled only by till. The outwash deposits may be excellent sources of water supply and in Fulton County are the most important of all water-bearing materials.

Alluvial deposits.—The youngest deposits in Fulton County are the alluvial silt, sand, and gravel of Recent time that are associated with the larger streams. They may be excellent aquifers, but in the County they are limited in areal extent.

GROUND WATER

SOURCE

Ground water has been defined by Meinzer (1923a, p. 38) as "that part of the subsurface water which is in the zone of saturation," but it is popularly thought of as the water that is obtained from wells and springs. Although it is pumped or issues freely from the ground, its source lies in the atmosphere, because practically all ground water initially is derived from rain and snow. In some areas subsurface conditions cause ground water to move many miles before it issues from the ground through wells or springs, but in Fulton County there is little long-distance movement and the subsurface reservoirs are replenished directly from precipitation on the immediate area. The precipitation is sufficient to meet all present demands. An inch of rain yields more than 17 million gallons of water per square mile; multiplying this by the average rainfall of 44 inches indicates that in Fulton County each square mile of land surface annually receives 750 million gallons of water. Thus a total of about 370 billion gallons of water falls on Fulton County each year. Of this, part runs off directly in the streams, a part evaporates or is transpired by plants, and the remainder seeps into the ground and recharges the water table. Although the supply of ground water generally varies directly with the amount of precipitation, other factors also control the rate of recharge. If the temperature is very high the rate of evaporation is correspondingly high, thus materially decreasing the potential supply of ground water. If the temperature is so low that the ground is frozen, an unusually high percentage of the water, finding its descent blocked, runs off directly into the streams. During the growing season the demands of both natural and cultivated vegetation make heavy inroads into the ground-water supply, but after the first killing frost this factor is largely eliminated.

OCCURRENCE

All rocks, regardless of their density, contain some pore spaces. Only those pores that are large enough, however, can release water to springs and wells tapping the rock. The amount and size of the openings or pore spaces and, therefore, the yields are directly related to the type of rock tapped. The percentage of total rock volume that is occupied by open space is a measure of the porosity of the rock. According to Meinzer (1923a, p. 3), the porosity of a sedimentary deposit depends chiefly on (1) the shape and arrangement of its constituent particles, (2) the degree of assortment of its particles, (3) the cementation and compaction to which it has been subjected since its deposition, (4) the removal of minerals through solution by percolating waters, and (5) the fracturing of the rock, resulting in joints and other openings.

Although the porosity indicates the total volume of pore space available for storing water, it is necessary to use the term *specific yield* to indicate the amount of water that will drain out of a rock because of the action of gravity, and the term *hydraulic permeability* to indicate the capacity of a rock for transmitting water under pressure. In general, owing to capillary forces, the smaller the interstices of a material, the lower will be its specific yield and hydraulic permeability. Thus clay and silt commonly have higher porosities than sand or gravel but yield considerably less water.

The water table is an undulating surface below which all rocks are saturated with water. The source of this water is the rainfall that percolates down from the surface. The water table is influenced by, but does not exactly reproduce, the configuration of the surface topography. Depth to the water table varies seasonally and annually with changes in precipitation, runoff, pumpage, temperature, and other related factors.

Under normal water-table conditions water will stand in a well at a height corresponding to that of the water table. When an aquifer is underlain and overlain by impermeable beds that confine the water under pressure, an artesian system is created and water will rise in the tightly cased well above the upper confining bed and may flow out of the well. Artesian conditions suitable to produce a flowing well are not common in Fulton County. Only four wells, Fu 52, 60, 88, and 186 have been reported to flow, and each well represents favorable local conditions. There is no evidence of any widespread artesian horizons in the County.

Pre-Cambrian rocks

The pre-Cambrian rocks are very compact dense crystalline and thoroughly cemented together. The rocks have a porosity that is probably less than 1 percent, but they are broken into blocks by many joints that form intersecting conduits in which ground water circulates. It is extremely difficult, if not impossible, therefore, to predict the existence of the joints and the presence of water in the pre-Cambrian rocks. Well Fu 80, penetrating 52 feet of the pre-Cambrian rocks, is reported to yield 20 gallons per minute (g. p. m.) and well Fu 64, penetrating the upper 20 feet of the pre-Cambrian, yields 13 g. p. m. Other wells, however, have yielded much less water. Well Fu 81

furnishes only one-quarter g. p. m. from 45 feet of rock, and well Fu 140 is reported to furnish only 1 g. p. m. from 121 feet of the pre-Cambrian. Six wells in the pre-Cambrian rocks range from 40 to 125 feet in total depth and have an average depth of 78 feet. The joints tend to pinch out or close up with increased depth, and generally it has been observed that below a depth of 150 to 200 feet further drilling produces little additional water.

Cambrian formations

Potsdam sandstone and Theresa dolomite.—The Potsdam sandstone and Theresa dolomite underlie a very small area in Fulton County. Because of this and because neither is very porous nor has an extensive joint system, wells tapping these formations have small yields. Well Fu 141, the only well in the Potsdam for which a record was obtained, has a yield of 3 g. p. m. The type of pump used at wells Fu 169 and 170, both of which end in the Theresa, indicates that no more than 3 to 4 g. p. m. is obtained. This, of course, does not preclude the possibility of the dolomite yielding more to a pump of larger capacity, but in general, yields from the Potsdam and Theresa may be expected to be small.

Little Falls dolomite.—The Little Falls dolomite is a compact, dense rock containing few pore spaces. It is broken by numerous joints, however, that have been enlarged by solution of the dolomite along the joint and bedding planes. The solution channels form excellent paths for movement of water, but like the joint systems of the pre-Cambrian rocks, the existence of the channels is difficult to predict. The yields of the wells tapping the dolomite, therefore, range considerably. In all, 13 wells are reported to obtain water from the Little Falls dolomite and the yields range from about 2 to 40 g. p. m. and average 9 g. p. m. The wells range in depth from 42 to 301 feet and average 124 feet in depth. Most wells in the Little Falls dolomite will probably furnish a sufficient supply for household use, but obtaining a more ample supply depends largely on the chance that the well intersects several solution channels.

Ordovician formations

Limestones.—The Lowville, Amsterdam, and Glens Falls limestones are all compact, dense rocks having little pore space but as in the Little Falls dolomite, solution channels and cavities are formed by the dissolving action of circulating waters. Only nine wells have been reported that tap the limestones, seven in the Glens Falls, and one each in the Amsterdam and Lowville. The average yield is about 5 g. p. m. Well Fu 137, for which a yield of 30 to 40 g. p. m. is reported, penetrates 146 feet of rock, and as the total thickness of limestone in the area is approximately 50 feet, this well probably obtains most of its water from the underlying Little Falls dolomite. Well Fu 155, a dug well 15 feet deep, penetrates 1 foot into the Amsterdam limestone. The well is cased loosely in the overlying drift, however, and the water probably is obtained largely from the 14 feet of overburden.

Canajoharie shale.—The Canajoharie shale is a dense impermeable rock which in some areas prevents the surface waters from percolating farther downward. In Fulton County, however, the shale has many joints that provide excellent passageways for the movement of ground water. The joints are similar to those in the other rocks in the area, however, and it is not possible to predict accurately their position beneath the land surface. The yields obtained from wells in the Canajoharie, therefore, range considerably and depend on the number of joints intersected. Reported yields range from 2 to 22 g. p. m. and the average yield for the 34 wells listed in this report is 5 g. p. m. The wells range in depth from 13 to 365 feet and average 135 feet in depth. Yields from the Canajoharie generally decrease with depth as the joints tend to become tighter and pinch out, and it generally is inadvisable to continue drilling to depths much more than 150 feet in the shale if sufficient water has not already been obtained.

Quaternary deposits

Glacial deposits.—Brigham (1929, p. 48) estimates that the glacial deposits in Fulton County have an average thickness of 30 feet. Glacial deposits yield water to 128 of the 191 wells for which information has been obtained. Of these 128, 6 are driven wells, 41 are drilled wells, and 81 are dug wells.

Till, in one form or another, serves as the aquifer for about 80 percent of the wells tapping the glacial deposits. Although largely unsorted and relatively impervious, the till is unconsolidated and comparatively easy to excavate. Therefore, by means of the dug well, which possesses a large infiltration area and a large storage capacity, the till has become the source of water supply for many of the farms and households in the area. The average yield from dug wells in till is less than 3 g. p. m. The depths of 52 wells in the till range from 5 to 265 feet and average 26 feet.

Intermingled with the till are lens-shaped outwash deposits that differ greatly in lithologic properties and are difficult to trace for any distance. Drilled wells, which can penetrate a greater thickness of drift than the dug wells, may encounter these lenses and obtain larger yields from them than wells obtain from tapping the till. Records of 20 wells penetrating outwash deposits show yields that range widely but average more than 10 g. p. m. Many of the yields, however, reflect the maximum capacity of the pump at the well, and the outwash probably is capable of supplying much larger quantities of water than is indicated. The municipal well at Broadalbin (Fu 131) yields 125 g. p. m. from a gravel layer. Depths of 61 wells penetrating outwash deposits range from 7 to 223 feet and average 67 feet. Outwash deposits constitute the most productive aquifers in the County and if modern methods of well completion were employed (see section "Recovery") the deposits could be a source of large industrial and municipal supplies.

Alluvial deposits.—Deposition of silt, sand, and gravel in Recent time has built up a series of stratified alluvial deposits in some of the river valleys of the area. The exact areal extent and thickness of these deposits is not known accurately, but most of the deposits are believed to be small and thin. Only one well definitely is known to obtain water from the alluvium. Well Fu 89, a dug well 14 feet square and 14 feet deep, obtains water from alluvial deposits of Cayadutta Creek. During pumping test at the well, 400 g. p. m. were obtained with a drawdown of about 11 feet after pumping 8 hours. After approximately a 2-hour recovery period the water had returned nearly to its original level. On the basis of this one well, it may be said that alluvial deposits in the County which are subject to surface-water recharge, may constitute a good source of ground water capable of meeting small industrial demands.

RECOVERY[3]

Ground water in Fulton County primarily is recovered from wells. Of these, the majority are shallow dug wells of large diameter that obtain water from unconsolidated materials. Nearly all of the remainder are drilled wells that obtain water from the bedrock or the overburden. In addition to the dug wells and drilled wells, a few small-diameter driven wells obtain water from the overburden.

Dug wells

The percentage of dug wells in Fulton County is comparatively high compared to that of other areas in the State. This is due to several factors. Most of the County, particularly the western and northern parts, is sparsely populated. The inhabitants live primarily on farms that are not equipped with many modern water-consuming devices or facilities, and consequently the dug well, with its modest yield and low cost, generally has sufficed. Another factor is that until recently no full time well driller resided in the area. Anyone wishing to have a well drilled had to bring in a driller from another county, and the additional cost of moving the drilling equipment over long distances was often a deterring factor. In addition, as drillers generally are paid according to footage drilled, they often hesitate to work in strange areas because of fear of obstacles that would materially slow down operations and thus decrease profits. Sixty percent of Fulton County is underlain by very hard pre-Cambrian rocks through which drilling is always very slow, and this also has tended to discourage extensive drilling operations. Within recent years, however, overflow of the urban population beyond the area served by municipal water supplies has created a large demand for private supplies, and this, coupled with the location of a well drilling company in Gloversville, has resulted in a sharp increase in the number of the new wells being drilled.

Dug wells are found mainly in the rural areas and are used primarily for domestic and farm purposes. Most are 2 to 3 feet in diameter and 10 to 20 feet in depth, but some are as much as 5 feet in diameter and 46 feet in depth. The large infiltration area provided by a dug well enables it to obtain water from relatively poor water-bearing materials. This factor, coupled with the large reservoir facilities provided, makes the dug well satisfactory for many homes and farms. This type of well, however, may yield no water during protracted dry periods when the water table falls below the shallow-well bottom. In addition, most wells of this type have a dry-laid stone or brick casing that has innumerable openings that may permit the inflow of polluted surface and shallow-soil waters. Construction of a satisfactory dug well requires careful sealing against pollution from surface sources as well as adequate depth to assure an unfailing water supply during drought periods.

Drilled wells

The drilled wells in Fulton County are almost all 6 inches in diameter and supply water for farm, domestic, and commercial purposes. Those obtaining water from rock generally are cased down to the rock, and left open below. If the casing is properly seated in the rock, all surface water and any water in the overlying unconsolidated materials are kept out and water enters only from

[3] For a complete discussion of wells, well-drilling equipment, and drilling techniques see the section "Recovery" in GW-20 or 21 listed in table 7 at the end of this report.

joints and solution openings in the rock. The drilled wells that obtain water from the unconsolidated materials, however, are cased to the bottom of the well and the water can enter only through the small area at the bottom of the casing. This method does not take full advantage of the yield potential of the source material, and much larger quantities of water could be withdrawn from the same sediments if more modern and efficient methods of well finishing were employed.

The efficiency of a well can be raised by increasing the intake area. This decreases the velocity of the water entering the well, decreases the frictional losses, and consequently increases the amount of water that can be withdrawn with a minimum lowering of the water level. The amount of lowering of the water level caused by pumping is known as *drawdown*, and it may be measured for a given quantity of water pumped during a specified period, or it may be measured after the level of the water surface in the well has become constant during pumping at a steady rate. The yield per unit of drawdown is known as the *specific capacity* of a well, and it generally is expressed in gallons per minute per foot of drawdown. For example, well Fu 131, the Broadalbin municipal well, is reported to yield 125 g. p. m. with a drawdown of 15 feet. This gives a specific capacity of about 8 gallons per minute per foot of drawdown. The efficiency of a well is measured in large part by its specific capacity and, therefore, if by increasing the intake area of the well the specific capacity can be raised, then the well has been made more efficient.

A relatively simple method of increasing the intake area of a well is to perforate the portion of the casing opposite the water-bearing beds. Those perforations may become clogged by sand and other fine material drawn up through the open bottom, however, and a better method is to plug the bottom and install a screen opposite the water-bearing horizon. A mechanical analysis of the water-bearing material should be made in order to determine the size of the screen openings to be used. Maximum intake area is thus combined with maximum protection against sand clogging. The following table shows the intake areas of wells when finished in different ways:

Table 2.—Approximate area of intake openings of open-end casings, perforated casings, and well screens

Diameter of casing (inches)	Intake area of open-end casing (square inches)	Intake area of 5-foot length of perforated casing and well screen, closed end (square inches)		
		Casing perforated with ¼-inch holes on 3-inch centers	Well screen	
			Intake area 10 percent of screen area	Intake area 20 percent of screen area
12	113	14	226	452
6	28	7	113	226
4	13	5	76	151
2	3	2	38	75

Recognizing the advantages derived from a large intake area, the superiority of a screened well over the other types is readily seen.

Springs

In addition to wells, ground water also is recovered from springs. Fulton County, particularly in the western part, has many springs, and although most are sixth magnitude or lower, that is have a flow of less than 10 g. p. m. (Meinzer, 1923b, p. 53), they provide an ample supply of water to the farms and homes where they are utilized. They are primarily gravity springs of the contact and depression types. In the former the water issues from permeable material because an underlying formation of impermeable or less permeable material prevents percolation farther downward. In the depression type, the water flows from permeable material where the water table intersects the ground surface. Several springs of higher magnitude are found along the Noses fault and its extensions in the eastern part of the County. The exact nature and discharge of these springs is not known definitely, but one of them, Fu 16Sp, (table 3), is probably of the fourth magnitude, having a yield estimated at 140 g. p. m. This spring furnished a major part of the Gloversville municipal supply before the present surface-water system was installed. Two other springs, Fu 19Sp and Fu 18Sp, contribute large quantities of water to the municipal systems of Northville and Sacandaga.

Table 3.—Records of selected springs in Fulton County, N. Y.

Location: for explanation of location symbols see section entitled, "Methods of investigation."
Altitude: approximate altitude from topographic map.

Use: Com, commercial; Dom, domestic; PWS, public water supply.

Spring number	Location	Owner	Altitude above sea level (feet)	Topography	Geologic subdivision	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Fu 1Sp	9U, 4.1N, 0.3W	Herman Rice	750	Hillside	Pleistocene gravel	..	..	Farm	
Fu 2Sp	8U, 13.3S, 0.6E	Ross Johnson	860	do.	do.	..	..	Farm	
Fu 4Sp	8U, 14.7S, 1.6E	S. Schuyler	680	Valley	do.	..	..	Dom	
Fu 5Sp	8U, 11.1S, 3.4E	W. E. Frye	1,090	Swamp	do.	..	..	Dom	
Fu 6Sp	8U, 13.7S, 6.0E	Henry Vedder	1,095	Valley	do.	..	..	Farm	
Fu 7Sp	8U, 9.1S, 5.7E	Clyde Van Allen	1,360	Upland	Pleistocene sand	10+	50	Dom	Not in use at present.
Fu 8Sp	8U, 7.4S, 6.8E	Evan Hughes	1,570	Hillside	Pleistocene gravel	2.5	..	Farm	
Fu 9Sp	8U, 14.0S, 8.0E	Norman Smith	1,230	do.	do.	2.5	43	Farm	[a]
Fu 11Sp	8U, 13.0S, 8.5E	Arthur Cromer	1,385	do.	Pleistocene sand	..	50	Dom	
Fu 12Sp	8U, 16.0S, 10.9E	Harold Wood	920	do.	Canajoharie shale	1.5	41	Farm	[a]
Fu 13Sp	9V, 0.7S, 3.4E	Jesse Edick	480	do.	Pleistocene gravel	..	..	Dom	
Fu 14Sp	8V, 11.8S, 7.7E	Kingsboro Water Works	1,020	do.	Pleistocene deposits	..	..	PWS	[a]
Fu 15Sp	8V, 9.5S, 10.3E	City of Gloversville	1,020	do.	..	..	..	PWS	Not in use at present.
Fu 16Sp	8V, 8.7S, 11.2E	do.	1,120	do.	..	140	..	PWS	do.
Fu 17Sp	8W, 3.5S, 1.5E	Fonda, Johnstown and Gloversville R. R.	1,400	do.	Pre-Cambrian rocks	..	..	PWS	
Fu 18Sp	8W, 2.3S, 2.9E	High Rock Lodge	980	do.	do.	..	..	Com	
Fu 19Sp	8W, 0.4S, 4.3E	Northville Water Works	840	do.	do.	..	..	PWS	

[a] For chemical analysis see table 4

UTILIZATION

Data for this report have been gathered for 219 wells and springs, and of these 88 percent supply water wholly or partly for domestic or farm purposes (tables 3 and 6). Of the remainder, 7 wells supply water for drinking purposes at schools, 12 wells and 1 spring supply water at camps, restaurants, and hotels for drinking and domestic purposes, 3 wells supply water for industrial purposes, and 2 wells are used for municipal supplies.

Except in the seven communities that have municipal systems, domestic-water supplies throughout the County are obtained almost exclusively from wells and springs. The domestic uses of water include drinking, cooking, washing, and sewage disposal, and water for these is normally supplied by the average dug or drilled well that yields 3 g. p. m. or more. Water for farm animals is also obtained by the same method, and where the number of stock to be cared for is small, one well may suffice for both farm and domestic purposes.

At least 12 of the many camps, hotels, roadside restaurants, and taverns in Fulton County use ground water for drinking and similar purposes. Of these, 9 have drilled wells and 3 have dug wells, and the average yield is about 5 g. p. m. The pumpage from well Fu 64, which is representative of the group, is estimated to be about 1,000 gallons per day (g. p. d.). In table 6, in the column headed "Use," these wells are listed as Commercial.

Records were obtained for seven wells at school houses. Of these, four were drilled wells, two were dug, and one was driven. All yields reported were less than 5 g. p. m., and as the water used by these schools is almost wholly for drinking purposes, the total amount consumed is believed to be small. In table 6, in the column headed "Use," these wells are listed as Domestic.

Most of the industrial activity in Fulton County is concentrated in the urban areas and large demands for water for industrial purposes are met by the municipal supplies. Records have been obtained for only three privately owned wells used exclusively for industrial purposes. Water from wells Fu 86 and 87 at Gloversville is used for refrigeration purposes. The Modern Tanning Co., also at Gloversville, has a large dug well (Fu 89) from which it formerly obtained about 80,000 g. p. d. This well has now been abandoned, and the plant obtains its water from the municipal supply. The larger dairies in the County generally are in the urban areas where they can obtain water from the municipal supplies. However, 10 farms obtain water from wells and springs for small pasteurization plants. The wells and springs also are used for domestic purposes and the exact amount of water used solely in the pasteurization plants is not known. An estimate based on the amount of milk processed, however, suggests that each plant uses less than 2,000 g. p. d.

Seven communities in Fulton County have public-water supplies. Only two of these, Mayfield and Broadalbin, use ground water. The systems of Gloversville, Johnstown, Northville, and Sacandaga are fed in part by springs, but essentially they are all surface-water supplies. Kecks Center purchases its water from Johnstown.

The Mayfield system consists of three springs, the water from which is piped to a 26-foot dug well and from there pumped to a 162,000 gallon elevated storage tank. The subsequent distribution is by gravity. The well (Fu 101) is in a sand and gravel bed along the southwest bank of the Sacandaga Reservoir. The water level in the well has risen 9 feet since the well was installed in 1924, and as the level of the Sacandaga Reservoir has risen similarly during the same period owing to damming, it is believed that in addition to being spring fed, the well also reflects local water-table fluctuations. The average daily consumption in Mayfield is about 63,000 gallons. The water is not treated. An analysis is given in table 4.

The Broadalbin public supply consists of a drilled well (Fu 131), 81 feet deep, that taps a gravel bed, and also two springs that are used only during dry seasons when the well cannot supply sufficient water to meet the demand. A test at the well is reported to have shown that continuous pumping at 125 g. p. m. caused a drawdown of 15 feet. The water is pumped into a 300,000-gallon storage tank and from there an average of 60,000 g. p. d. is distributed by gravity. There is no chemical treatment. An analysis of the water is given in table 4.

In addition to its municipal surface-water supply, Gloversville has a small privately-owned public system, the Kingsboro Water Works. This consists of three small reservoirs that are directly fed by underlying springs and which supply an average of 40,000 g. p. d. It is a gravity system and the only treatment is the addition of copper sulfate for the removal of algae.

QUALITY

Chemical characteristics of the ground water of Fulton County are indicated by the analyses in table 4. Analyses are given for 22 samples of ground water collected by the U. S. Geological Survey and analyzed in the laboratories of the New York State Health Department at Albany, N. Y., or by the U. S. Geological Survey, Quality of Water Branch, at Washington, D. C. The analysis for well Fu 118 was obtained from the files of Fred Tasker, well driller, and the analyses for Fu 75, 79, and Fu 14Sp were obtained from the files of the New York State Health Department. In addition, analyses of the waters from four municipal surface-water supplies are given. Two of the analyses, those of Northville and Sacandaga, were obtained from samples collected by the U. S. Geological Survey and analyzed at the State Health Department Laboratories, and two, those of Johnstown and Gloversville, were obtained from the files of the Health Department. Relative locations of the wells and springs for which analyses are available are shown in figure 9.

Chemical constituents and physical properties

Most of the following discussion relating to the data given in table 4 has been adapted from the work of W. D. Collins (1927, 1934) of the U. S. Geological Survey (Retired).

Dissolved solids.—The dissolved solids are the residue left upon evaporation of a water sample. The residue consists primarily of mineral matter, but a small quantity of organic material and a little water of crystallization are sometimes included. Water with less than 500 parts per million (one grain per U. S. gal. equals 17.1 parts per million) of dissolved solids is generally satisfactory for domestic use, except for possible difficulties such as excessive hardness or iron content. Water with more than 1,000 parts per million (p. p. m.) is likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in other respects. All the analyses of ground water in Fulton County show less than 1,000 p. p. m. of dissolved solids, and only two show more than 500 p. p. m. (See fig. 9.) The samples obtained from wells Fu 139, 63, and 89 show less than 60 p. p. m. of dissolved solids and are not greatly different in mineral content than the surface-water samples. Probably these three wells are recharged by surface water. With the exception of Fu 135, which shows the highest mineral content of any well sampled in the County, waters obtained from unconsolidated sediments show a lower dissolved solids content than waters from consolidated sediments.

Iron (Fe).—Iron is dissolved from many rock materials. If a water contains much more than 0.3 p. p. m. of iron, the excess may separate out when the water is exposed to the air and settle as a reddish sediment. Iron in the water sometimes stains cooking utensils and plumbing fixtures, and it is very troublesome to industries doing laundering, tanning, and paper manufacturing. Iron is found in noticeable amounts in many of the ground waters and surface waters of Fulton County. The municipal supply of Gloversville is given aeration, filtration, and coagulation for the removal of most of the iron. The analysis for well Fu 118 is the only one in table 4 that indicates an extremely high content of iron. The sample used for this analysis, however, was obtained by the driller immediately upon completion of the well. Samples thus obtained before a well has been subjected to a certain amount of pumpage may have an abnormally high iron concentration that is apparently derived from the newly installed casing.

Manganese (Mn).—Manganese also is dissolved from rock materials. When present in quantities greatly exceeding 0.05 p. p. m., it causes gray to black discolorations on many of the materials it contacts, it causes clogging deposits in piping, and it is particularly troublesome in laundry and textile plants. None of the analyses in table 6 show more than 0.05 p. p. m.

Chloride (Cl).—Chloride is dissolved in small quantities from many rock materials and is a major constituent of sea water. Sewage also may contain significant quantities of chloride, and in the past a chloride content higher than normal for the region was considered to be an indication of pollution. So many sources in addition to sewage supply chloride to natural waters, however, that its presence in more than normal quantities is no longer taken as a definite indication of pollution. Waters high in chloride may be corrosive. According to the U. S. Public Health Service a satisfactory drinking water should not have a chloride content in excess of 250 p. p. m. All except two of the ground-water supplies analyzed show less than 10 p. p. m. of chlorides, and this compares favorably with the surface-water supplies of the area. Wells Fu 49 and 135 show chloride contents of 175 and 48 p. p. m., respectively. This is high for the region, but is believed to reflect only local conditions at the well site.

Table 4.—Chemical analyses of natural waters from Fulton County, N. Y.

(Analyses by New York State Department of Health unless indicated otherwise. Dissolved constituents given in parts per million.)

Well or spring number	Depth (feet)	Geologic subdivision or surface source	Date of collection	Dissolved solids	Iron (Fe)	Manganese (Mn)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness (as $CaCO_3$)			Total alkalinity (as $CaCO_3$)	pH
										Total	Carbonate	Noncarbonate		
Fu 8	30	Canajoharie shale	12–19–46	251	0.8	0.00	265	18	1.2	260	217	43	217	7.6
Fu 28	125	Pleistocene deposits	7–30–46	178	.6	.05	162	11	.8	148	133	15	133	8.0
Fu 49	141	Lowville limestone	12–12–46	547	.8	.05	268	8.9	175	220	220	0	220	7.7
Fu 63	102	Pleistocene gravel	7–24–46	44	.03	.01	28	3.6	1.6	42	23	19	23	6.3
Fu 75	150	do.	.....	...	.07	...	148	...	2.0	152	121	31	121	8.1
Fu 79	190	do.	.....	...	1.5	...	110	....	1.0	60	60	0	90	8.2
Fu 80	102	Pre-Cambrian rock	1–28–47	79	.15	.00	49	2.4	1.2	46	40	6	40	7.7
Fu 81 [a b]	45	do.	9–14–47	108	.98	.00	104	8.2	.8	52	52	0	85	7.1
Fu 89	14	Recent gravel	6–13–46	59	.1	.00	33	12	1.0	22	22	0	27	7.9
Fu 98	25	Canajoharie shale	12–12–46	268	.25	.00	271	18	2.6	220	220	0	222	7.2
Fu 101	26	Pleistocene gravel	6–12–46	...	.2	.00	274	...	8.4	230	225	5	225	7.4
Fu 114	109	Pleistocene till	1–29–47	126	.5	.00	120	4.9	.2	84	84	0	98	8.0
Fu 118 [c]	134	Little Falls dolomite	10–..–46	...	10	...	133	...	3.0	94	94	0	109	7.4
Fu 122	65	Glens Falls limestone	1–29–47	246	.25	.00	218	23	2.4	230	179	51	179	7.6
Fu 131	81	Pleistocene gravel	6– 7–46	116	.05	.00	102	15	3.0	100	84	16	84	7.4
Fu 135	26	Pleistocene till	7–23–46	687	.06	.01	226	53	48	310	185	125	185	7.2
Fu 139	128	Pleistocene gravel	7–18–46	48	.6	.00	9	5.3	1.0	34	7	27	7	...
Fu 141	62	Potsdam sandstone	12– 4–46	198	.2	.01	66	23	4.0	116	54	62	54	7.9
Fu 146	117	Glens Falls limestone	1–29–47	113	.2	.02	111	3.8	1.0	84	84	0	91	8.0
Fu 155	15	Amsterdam limestone	12–12–46	378	.8	.02	249	31	7.8	240	204	36	204	7.2
Fu 161	100	Little Falls dolomite	12– 4–46	170	.15	.01	146	18	2.4	148	120	28	120	8.1
Fu 162	124	do.	12– 5–46	164	.15	.00	145	13	1.0	136	119	17	119	7.9
Fu 170	50	Theresa dolomite	1–28–47	332	1.0	.01	343	20	3.6	370	281	89	281	7.3
Fu 9 Sp	...	Pleistocene gravel	12–11–46	100	.15	.00	84	5.6	.6	68	68	0	69	7.7
Fu 12 Sp	...	Canajoharie shale	12–19–46	265	.03	.00	254	12	.6	240	208	32	208	7.5
Fu 14 Sp	...	Pleistocene deposits	9–19–46	...	.1	...	129	...	4.0	104	104	0	106	7.9
Hunter Creek, Northville public supply			12–11–46	47	.3	.00	12	6.1	2.0	16	10	6	10	6.9
Small Brooks, Sacandaga public supply			12–11–46	35	.5	.01	7	6.0	1.0	8	6	2	6	6.3
Small Brooks, Gloversville public supply			11–19–46	...	.05	...	29	...	.8	16	16	0	24	8.1
Small Brooks, Johnstown public supply			9–26–46	...	.07	...	116	...	1.8	108	95	13	95	7.7

[a] Analysis by U. S. Geological Survey.

[b] Silica, 9.1; calcium, 18; magnesium, 1.7; sodium and potassium, 20; fluorine, 0.0; nitrate, 0.0.

[c] Analysis obtained from Fred Tasker, Gloversville, N. Y.; laboratory unknown.

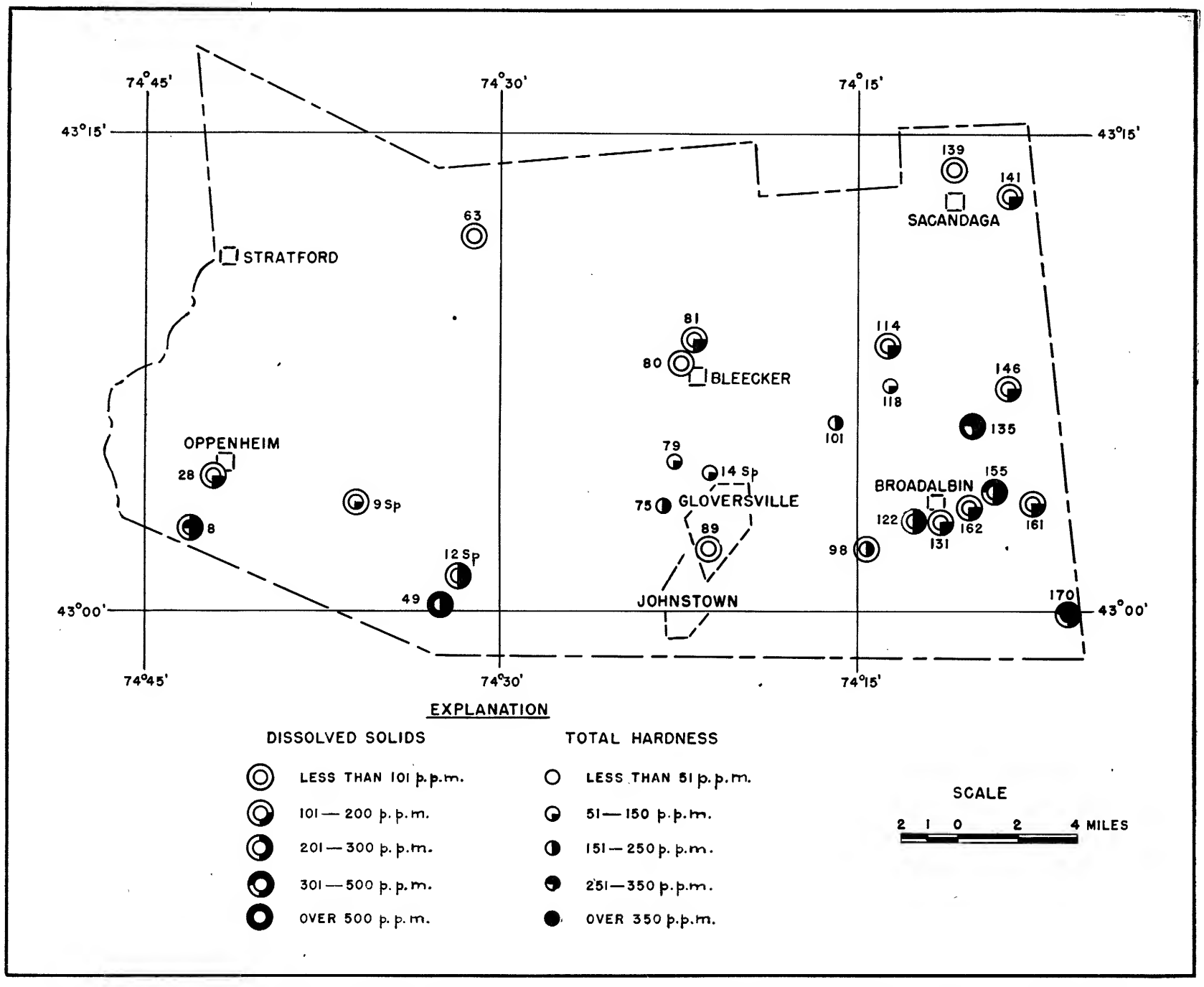


Figure 9.—Areal distribution of dissolved solids and total hardness in well and spring waters in Fulton County, New York.

Sulfate (SO_4).—Sulfate is dissolved in large quantities from gypsum and is formed from the oxidation of iron sulfides, principally pyrite. Sulfate in small amounts has little effect on the general use of a water but magnesium sulfate and sodium sulfate may be present in sufficient quantity to give a bitter taste. Sulfate in a hard water may increase the cost of softening and will form a hard adhering scale in a steam boiler. The U. S. Public Health Service states that a satisfactory drinking water should contain less than 250 p. p. m. of sulfate. All of the analyses except one show sulfate values of less than 35 p. p. m. Several wells tapping the Canajoharie shale have been reported to yield water high in sulfur. This is probably due to the presence of hydrogen sulfide gas which is believed to be formed by the reduction of sulfates in the shale.

Hardness.—Hardness of a water is recognized most commonly by the amount of soap required to form a lather in washing. In addition to increasing the consumption of soap, calcium and magnesium, the constituents that cause hardness, are also the active agents in the formation of the greater part of all the scale in steam boilers and in vessels in which water is heated or evaporated. Table 4 shows the total hardness as well as the carbonate and noncarbonate hardness of the waters analyzed. Carbonate hardness (temporary hardness), caused by the presence of calcium and magnesium bicarbonate, can be removed largely by boiling the water. The noncarbonate hardness (permanent hardness) is due to the presence of calcium and magnesium chlorides or sulfates that cannot be removed by boiling. The noncarbonate hardness generally forms a harder scale, but both consume the same amount of soap. Water with a hardness of less than 50 p. p. m. is rated generally as soft, and softening treatment rarely is justified. Hardness between 50 and 150 p. p. m. does not seriously interfere with the use of water for most purposes, but it does increase the consumption of soap. Accordingly softening may be profitable for laundries or other industries that use large quantities of soap. Treatment for the prevention of scale is necessary for the successful operation of steam boilers using water having a hardness approaching 150 p. p. m. Hardness in excess of 150 p. p. m. is noticeable to anyone, and where the hardness is 200 or 300 p. p. m. it is common practice to soften water for household use or to install cisterns to collect rain water. Where municipal water supplies are softened an attempt generally is made to reduce the hardness to about 60 p. p. m. The additional improvement from further softening an entire public supply is not deemed worth the additional cost.

The 30 analyses for Fulton County show a wide range in total hardness, and 9 of the waters analyzed had a hardness of more than 200 p. p. m. The average hardness of the waters analyzed is 146 p. p. m. (fig. 9). Surface water in this area generally is softer than the ground water.

Bicarbonate (HCO_3).—Bicarbonate in natural waters results from the solution of carbonate rocks (limestone, dolomite, and calcareous shale) through the action of carbon dioxide that is dissolved in the water. Together with any carbonate content of the water, the bicarbonate is often reported as alkalinity. All of the samples analyzed except one had a bicarbonate content of less than 300 p. p. m. Surface water, and water from those wells at which there is probably surface recharge generally show a lower bicarbonate content than do other ground waters.

Hydrogen-ion concentration (*pH*).—The hydrogen-ion concentration of a water is expressed by the unit pH, and its importance lies in its indication of the corrosiveness of the water. The pH of a water is the negative exponent of the concentration of hydrogen ions in grams per liter. Thus a low pH value means a high concentration of hydrogen ions, or a high acidic value, and a high pH value indicates a low concentration of hydrogen ions or a high alkaline value. A neutral water has a pH of 7.0. The waters analyzed from Fulton County show a range in pH from 6.3 to 8.2 and an average value of 7.6. The pH value should be determined immediately after the sample is collected, because contact of the water with the air changes the alkalinity. The analyses tabulated in table 4 were not made until several days after the samples were collected, and therefore the value of the figures obtained is somewhat indeterminate.

Temperature

Certain industries use water primarily for cooling or air-conditioning purposes and the temperature of the water may be of greater importance than its chemical quality. Waters with low temperatures are desirable, and waters of the same low temperature consistently throughout the year are preferred. In this respect ground water is vastly superior to surface water. The temperature of the latter directly reflects local atmospheric conditions and may vary from 32° to more than 80° F. throughout the course of a year. Ground water, however, regardless of the season, generally maintains a temperature that is only slightly above the mean annual temperature of the region. The mean annual air temperature at Fulton County is about 45° F. whereas the temperatures listed for 29 well and spring waters in tables 3 and 6 indicate an average of about 49° F. Of 29 samples,

13 were obtained during the months of June and July when the air temperature averaged 67° F., and 14 were obtained during the months of December and January when the air temperature averaged 24° F. Fu 89, a dug well 14 feet deep, for which table 6 indicates a temperature of 58° F. on June 13, 1946, was measured at 48° F. on January 29, 1927. Fu 135, a dug well 26 feet deep, showed temperature of 51° F. on July 23, 1946 and 48° F. on January 29, 1947. This is only a 3° drop as compared to the 10° of the more shallow well. While it is impossible to draw any definite conclusions on the basis of just two wells, the figures tend to bear out the belief that the temperature of water obtained from shallow, dug wells may generally be expected to vary seasonally more than that of water obtained from deeper wells.

Relation of water quality to rock type

Pre-Cambrian rocks.—Water from the pre-Cambrian rocks appears to have a lower mineral content than does water from any of the other consolidated deposits in the area. The hardness in both samples analyzed, Fu 80 and 114, was below 100 p. p. m.

Potsdam sandstone.—Only one sample (Fu 141) was obtained from the Potsdam sandstone. The analysis of this sample shows fairly low dissolved solids and a relatively soft water. However, the value for sulfate (23 p. p. m.) is relatively high for the County.

Theresa dolomite.—The one sample obtained from the Theresa dolomite (Fu 170) has a hardness of 370 p. p. m., the highest in the County. The water is also fairly high in sulfate and has the second highest iron content of any of the samples from consolidated deposits.

Little Falls dolomite.—Each of the three samples from the Little Falls dolomite (Fu 118, 162 and 161) has a hardness of less than 150 p. p. m. and in general is low in mineral matter with the possible exception of sulfates and iron. The figures obtained for the sulfates, 13 and 18 p. p. m., are low when compared to those in other areas. An iron content of 10 p. p. m. is reported for one well (Fu 118).

Ordovician limestones.—Three of the four analyses of water from the limestones of Ordovician age (Fu 49, 122, and 155) show a hardness of more than 200 p. p. m. and are high in other dissolved solids. Analysis of the water sample obtained from the Amsterdam limestone (Fu 155) shows 31 p. p. m. of sulfates, the highest in the County for consolidated sediments, and analysis of the sample from the Lowville limestone (Fu 49) shows 175 p. p. m. of chlorides. The fourth water sample (Fu 146) obtained from the Glens Falls limestone differs from the others in that it is low in dissolved solids and shows a hardness of only 84 p. p. m. This suggests possible variations in the lithology of the Glens Falls.

Canajoharie shale.—Each of the three samples obtained from the Canajoharie shale (Fu 8, 98, and Fu 12Sp) has a total hardness of more than 200 p. p. m. but is otherwise fairly low in dissolved solids. The analyses do not indicate the high sulfur content that is so often reported in waters from this shale.

Glacial deposits.—The 11 analyses of waters obtained from glacial deposits (Fu 131, 139, 114, 101, 28, 75, 79, 135, 63, Fu 14Sp, and 9Sp) show a wide variation of chemical characteristics. The hardness ranges from less than 50 to more than 300 p. p. m.; the iron content from the lowest reported in the area, 0.03 p. p. m., to the highest, 10 p. p. m.; and the chlorides from 0.2 p. p. m., very low for the area, to 48 p. p. m., the second highest figure reported. The quality of water obtained from the glacial deposits appears to be determined locally by the type of rock from which the glacial deposits were derived. This in many places is the bedrock of the immediate area. Four of the samples, Fu 79, 139, 63, and Fu 9Sp were obtained from glacial deposits overlying the pre-Cambrian, whereas the others were from glacial deposits overlying the Little Falls dolomite or the Canajoharie shale. Figures for dissolved solids were not available in all analyses, but those for hardness indicate that the glacial deposits underlain by the sedimentary rocks yield water with a hardness of 100 p. p. m. or more, whereas the glacial deposits underlain by the dense, well-cemented pre-Cambrian rocks yield waters that have a hardness of less than 70 p. p. m.

Alluvial deposits.—The analyzed sample (Fu 89) from an alluvial deposit has a very low content of dissolved solids, and has a hardness of only 22 p. p. m. This analysis compares very favorably with those of surface waters in the County and there is a strong possibility that the well is subject to recharge from surface-water sources.

SUMMARY OF GROUND-WATER CONDITIONS

The rain and snow that falls on Fulton County is the source of the region's ground-water supply. No extensive subterranean flow of ground water into the County from adjacent areas is indicated.

Ground water in Fulton County is recovered chiefly by means of dug and drilled wells. Of the total of 219 wells for which records were obtained, 104 were drilled, 81 were dug, and 6 were driven. The dug well, having a large infiltration area, is used chiefly on farms to obtain a water supply from the glacial deposits. Yields usually are small, averaging less than 3 g. p. m.; generally this meets all needs. Drilled wells also are used primarily for domestic and farm supplies but generally only where the glacial covering is thin or otherwise unproductive or where there is a likelihood of contamination or an uncertainty of supply during dry periods. There is little industrial demand for ground water in Fulton County. Most industry is in urban areas that have municipal surface-water supplies capable of supplying water at so low a price rate that the risk and cost of establishing a private individual ground-water system generally is not warranted. It is expected in the future, however, that several plants will install wells in order to take advantage of the constant low-temperature feature of ground water.

Ground water generally occurs throughout the County under water-table conditions. Several flowing wells have been reported, but probably they are caused by local conditions; no extensive artesian aquifers are known.

The chief water-bearing rocks of the area are the pre-Cambrian rocks, the Little Falls dolomite, and the Canajoharie shale. All are dense, compact, impervious rocks that yield water only from joints, bedding planes, or solution channels. Openings of this nature are difficult to predict and generally tend to pinch out with depth. The yields obtained from the rock wells, therefore, range considerably. Yields ranging from less than 1 to 40 g. p. m. have been reported. The Little Falls dolomite has an average yield of 9 g. p. m. and is the most productive consolidated aquifer. The quality of water depends upon the source formation. Water from the well-cemented insoluble pre-Cambrian rocks is softer and lower in dissolved solids than water obtained from the dolomite. The water obtained from the soft calcareous Canajoharie shale is the hardest and possesses the highest total of dissolved solids of the three.

The unconsolidated glacial deposits are the chief water-bearing sediments of the area. They range from unsorted till through well-sorted outwash deposits, and accordingly yields range considerably. The till yields less than 3 g. p. m. to dug wells, whereas outwash deposits yield an average of more than 10 g. p. m. to drilled wells. The latter figure, however, would be considerably higher if modern methods of well drilling and well developing were employed. Under such conditions the glacial deposits could be expected to yield supplies large enough for industrial and municipal use. One of the most promising areas for future development in the County is in the vicinity of Gloversville, in what may be a buried preglacial valley of the Sacandaga River.

The quality of the water obtained from the glacial deposits also varies considerably and in many places reflects the character of the underlying bedrock. Glacial deposits overlying the hard dense pre-Cambrian rocks yield softer water than do deposits overlying the shales and dolomites, which consist of calcareous minerals easily taken into solution.

The unconsolidated deposits are the most productive aquifers in the County and constitute the only source from which future demands for large quantities of water can be satisfied.

REFERENCES

Brigham, A. P., 1929, *Glacial geology and geographic conditions of the lower Mohawk Valley:* New York State Mus. Bull. 280.

Collins, W. D., and Howard, C. S., 1927, *Chemical character of waters of Florida:* U. S. Geol. Survey Water-Supply Paper 596-G.

Collins, W. D., Lamar, W. L., and Lohr, E. W., 1934, *The industrial utility of public water supplies in the United States:* U. S. Geol. Survey Water-Supply Paper 658.

Cushing, H. P., 1905, *Geology of the vicinity of Little Falls, Herkimer County:* New York State Mus. Bull. 77.

Darton, N. H., 1897, *A preliminary description of the faulted region of Herkimer, Fulton, Montgomery and Saratoga Counties:* New York State Geol. 14th Ann. Rept.

Fuller, M. L., 1905, *Underground waters of eastern United States:* U. S. Geol. Survey Water-Supply Paper 114.

Goldring, Winifred, 1931, *Handbook of paleontology for beginners and amateurs, Part 2; The formations:* New York State Mus. Handbook 10.

Kay, G. M., 1937, *Stratigraphy of the Trenton group:* Geol. Soc. America Bull., vol. 48, pp. 233-302.

MacClintock, Paul and Apfel, E. T., 1944, *Correlation of the drifts of the Salamanca re-entrant, New York:* Geol. Soc. America Bull., vol. 55, pp. 1143-1164.

Megathlin, G. R., 1938, *Faulting in the Mohawk Valley, N. Y.:* New York State Mus. Bull. 315.

Meinzer, O. E., 1923a, *The occurrence of ground water in the United States with a discussion of principals:* U. S. Geol. Survey Water-Supply Paper 489.

Meinzer, O. E., 1923b, *Outline of ground-water hydrology with definitions:* U. S. Geol. Survey Water-Supply Paper 494.

Miller, W. J., 1911, *Geology of the Broadalbin quadrangle, Fulton-Saratoga Counties, N. Y.;* New York State Mus. Bull. 153.

Miller, W J., 1924, *The geological history of New York State:* New York State Mus. Bull. 255.

Table 5.—Selected well logs from Fulton County, N. Y.

(Altitudes are approximate distance above mean sea level as taken from topographic maps)

		Thickness (feet)	Depth (feet)
Fu 20;	8U, 4.9S, 3.3E; drilled by C. Perry in 1945; altitude 1,160 feet.		
	Gravel, sand, and stones	42	42
	Gravel	3	45
Fu 21;	8U, 0.7S, 4.9E; drilled by N. A. Crandall, altitude 1,500 feet.		
	Gravel, coarse, sand, and boulders	50	50
	Sand and gravel	10	60
Fu 61;	8V, 12.4S, 0.1E; drilled by Hall and Co., Inc., in 1941; altitude 1,100 feet.		
	Hardpan and boulders	42	42
	Sand and gravel with clay binder	18	60
	Gravel	5	65
Fu 90;	8V, 14.4S, 8.5E; drilled by Tasker Water Wells in 1946; altitude 840 feet.		
	Sand	10	10
	Clay, blue	245	255
Fu 115;	8W, 7.8S, 0.6E; drilled by C. Smith; altitude 800 feet.		
	Clay, hardpan, and boulders	70	70
	Sand and gravel	7	77
Fu 123;	8W, 16.6S, 1.6E; drilled by Tasker Water Wells in 1945; altitude 950 feet.		
	Clay, blue	100	100
	Sand	100	200
Fu 125;	9W, 1.1S, 2.8E; drilled by H. Provost and Sons in 1941; altitude 750 feet.		
	Topsoil	20	20
	Sand, fine and some clay	38	58
	Hardpan	56	114
	Clay and sand	58	172
Fu 128;	8W, 16.2S, 2.8E; drilled by Hall and Co., Inc., in 1944; altitude 850 feet.		
	Hardpan and boulders	80	80
	Sand, black	5	85
	Glens Falls limestone	22	107
Fu 132;	8W, 13.5S, 2.3E; drilled by Hall and Co., Inc., in 1940; altitude 800 feet.		
	Hardpan and boulders	44	44
	Gravel	2	46
Fu 157;	8W, 11.5S, 5.3E; drilled by Mohawk Drilling Co.; altitude 885 feet.		
	Sand	45	45
	Hardpan	29	74
	Sand	11	85
	Little Falls dolomite	6	91
Fu 165;	8W, 14.1S, 4.9E; dug well; altitude 950 feet.		
	Muck, black	2	2
	Sand, white	18	20
	Clay and hardpan	15	35

Table 5.—Selected well logs from Fulton County, N. Y. (Concluded)

		Thickness (feet)	Depth (feet)
Fu 172;	8V, 14.2S, 9.1E; drilled by Tasker Water Wells in 1946; altitude 900 feet.		
	Sand, white	100	100
	Gravel	25	125
	Canajoharie shale	16	141
Fu 179;	8V, 14.6S, 10.4E; drilled by E. Sanders in 1936; altitude 940 feet.		
	Sand	100	100
	Sand and gravel	28	128
	Canajoharie shale	7	135
Fu 183;	8V, 14.2S, 6.6E; drilled by W. Reed in 1940; altitude 940 feet.		
	Sand	100	100
	Clay, blue	50	150
	Canajoharie shale	10	160

Table 6.—Records of selected wells in Fulton County, New York

Location: for explanation of location symbols see section, "Method of investigation."
Altitude: approximate altitude from topographic map.
Type of well: Drl, drilled; Drv, driven.
Water level: reported average water level.
Method of lift: for explanation of methods of lift and pumping equipment see section, "Recovery."
Use: Com, commercial; Dom, domestic; Ind, industrial; PWS, public water supply.

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 1	9U, 5.8N, 0.5W	Steve Polansky	790	Dug	30	36	...	Pleistocene till	22	Force	..	Dom	
Fu 2	8U, 10.9S, 0.3E	Hobart Jaiken	880	Dug	17	36	...	do.	10	do.	..	Dom	
Fu 3	8U, 11.4S, 0.8E	Harry Kelly	950	Dug	22	..	...	do.	11	do.	3	Farm	
Fu 4	8U, 11.7S, 1.4E	Cornelius Stowell	1,000	Dug	46	48	...	Pleistocene gravel	20	Suction	..	Farm	
Fu 5	8U, 14.6S, 0.8E	C. Allen	680	Dug	30	..	...	Pleistocene deposits	18	Force	..	Dom	
Fu 6	8U, 13.7S 1.4E	James Trumbull	880	Dug	12	..	...	Pleistocene till	10	..	..	Farm	
Fu 7	8U, 13.7S, 1.7E	Ivan Gray	980	Dug	...	..	...	do.	20	Pitcher	..	Dom	
Fu 8	8U, 14.8S, 2.4E	M. D. Groff	880	Drl	30	6	...	Canajoharie shale	..	Force	..	Farm	Temperature 48° F. [a]
Fu 9	8U, 13.7S, 2.4E	Roy Sammons	950	Dug	14	48	...	Pleistocene till	8	do.	3	Dom	
Fu 10	8U, 13.6S, 2.6E	Reed Elwood	960	Dug	30	..	...	do.	24	do.	..	Dom	
Fu 11	8U, 13.6S, 2.7E	Steven Sokol	1,020	Dug	10	..	...	do.	..	Suction	..	Farm	
Fu 12	8U, 13.1S, 2.6E	R. Voorhees	1,060	Dug	30	36	...	do.	15	do.	..	Farm	
Fu 13	8U, 13.0S, 2.2E	B. Olsen	1,020	Dug	16	..	...	do.	10	Force	..	Dom	
Fu 14	8U, 11.4S, 1.9E	A. Alkinburga	1,020	Dug	11	48	...	do.	7	Suction	..	Dom	
Fu 15	8U, 11.3S, 2.1E	Andrew Hudach	1,080	Dug	20	36	...	do.	20	Force	..	Dom	
Fu 16	8U, 9.4S, 2.7E	Clyde Fitzer	1,140	Dug	25	36	...	do.	17	do.	..	Dom	
Fu 17	8U, 6.8S, 2.1E	Joseph Ellis	1,000	Dug	18	36	...	do.	9	..	..	Com	
Fu 18	8U, 4.9S, 3.0E	James McGowan	1,100	Drl	98	6	...	Pleistocene Gravel	..	Jet	..	Dom	
Fu 19	8U, 5.0S, 3.1E	Stratford Garage	1,140	Drl	100	6	...	do.	..	..	5	Com	
Fu 20	8U, 4.9S, 3.3E	Ford Perkins	1,160	Drl	45	6	...	do.	10	Suction	..	Dom	[b]
Fu 21	8U, 0.7S, 4.9E	John F. Thomas	1,535	Drl	60	6	...	do.	15	do.	..	Dom	[b]
Fu 22	8U, 6.9S, 3.1E	L. Cool	1,090	Dug	16	36	...	do.	10	Force	..	Dom	
Fu 23	8U, 6.5S, 4.2E	Alphonse Aubin	1,270	Dug	7	36	...	Pleistocene till	4	Pitcher	..	Dom	
Fu 24	8U, 7.2S, 4.4E	Earl Van Alstyne	1,270	Dug	14	48	...	Pleistocene deposits	11	Force	..	Dom	
Fu 25	8U, 9.8S, 3.7E	Maude Jacobwin	1,170	Dug	16	36	...	Pleistocene till	12	do.	..	Dom	
Fu 26	8U, 11.7S, 3.3E	Dominick Sanks	1,125	Dug	35	36	...	do.	20	do.	..	Dom	
Fu 27	8U, 12.4S, 2.9E	Lloyd Brown	1,100	Drl	121	6	...	Pleistocene gravel	21	do.	5	Dom	Drawdown reported 100 feet when pumped at 5 gallons per minute.
Fu 28	8U, 12.5S, 2.8E	D. M. Hartnett	1,100	Drl	125	6	...	do.	25	Jet	3	Dom	Drawdown reported 100 feet when pumped at 3 gallons per minute. [a]
Fu 29	8U, 12.7S, 3.2E	Reuben Gray	1,040	Dug	22	..	...	Pleistocene till	20	Suction	...	Farm	

See footnotes at end of table.

Table 6.—Records of selected wells in Fulton County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 30	8U, 13.6S, 11.5E	Virgil Claus	1,030	Dug	20	..	...	Pleistocene till	18	Force	..	Dom	
Fu 31	8U, 15.0S, 3.3E	Floyd Groff	940	Dug	30	..	...	Pleistocene deposits	20	Suction	..	Farm	
Fu 32	8U, 15.5S, 5.5E	Charles Seaman	1,000	Dug	30	..	...	do.	..	Force	..	Dom	
Fu 33	8U, 14.6S, 5.8E	Murray Bell	1,100	Drl	90	6	...	Pleistocene sand	..	do.	..	Farm	
Fu 34	8U, 14.5S, 5.4E	Alvene Bell	1,080	Dug	42	..	...	Pleistocene till	20	do.	..	Dom	
Fu 35	8U, 13.6S, 5.5E	Adam Hayes	1,110	Dug	30	36	...	Pleistocene gravel	5	Suction	..	Farm	
Fu 36	8U, 13.4S, 4.9E	Clarence McArthur	1,220	Dug	26	36	...	Pleistocene till	3	Force	..	Dom	
Fu 37	8U, 13.0S, 5.3E	Cleber Keck	1,210	Dug	25	36	...	do.	20	do.	..	Farm	
Fu 38	8U, 12.6S, 4.5E	A. Hayes	1,110	Dug	14	48	...	do.	..	do.	..	Dom	Well goes dry during periods of low precipitation.
Fu 39	8U, 7.5S, 6.1E	John Hall	1,470	Dug	8	36	...	do.	7	Bucket	..	Dom	Well serves two households.
Fu 40	8U, 13.9S, 7.3E	Karey Weaver	1,110	Dug	13	24	...	Pleistocene gravel	8	Pitcher	3	Dom	
Fu 41	8U, 13.9S, 7.4E	Edward Bronk	1,140	Dug	11	..	...	do.	9	Suction	..	Dom	
Fu 42	8U, 14.0S, 7.4E	C. Van Gorder	1,140	Dug	21	24	...	do.	17	do.	..	Dom	
Fu 43	8U, 12.6S, 8.5E	A. Miles	1,380	Dug	10	36	...	do.	4	do.	..	Dom	
Fu 44	8U, 12.5S, 9.0E	Lydia Cretser	1,440	Dug	17	60	...	Pleistocene till	8	do.	..	Dom	
Fu 45	8U, 12.5S, 9.4E	Peter Cromer	1,400	Dug	15	..	...	do.	..	Force	..	Dom	
Fu 46	8U, 14.2S, 9.4E	Josephine Johnson	1,320	Drv	60	..	...	Pleistocene gravel	..	Suction	..	Dom	
Fu 47	8U, 16.2S, 9.5E	W. G. Wilder	980	Dug	10	..	...	Pleistocene deposits	..	Force	..	Dom	
Fu 48	8U, 16.4S, 10.2E	Clark Dockstader	950	Dug	26	..	...	Pleistocene till	..	do.	..	Dom	Temperature 50° F.
Fu 49	9V, 0.1S, 2.6W	Frances Putnam	720	Drl	141	6	120	Lowville limestone	50	Jet	7	Dom	Temperature 48° F.[a]
Fu 50	8U, 16.5S, 10.5E	Lilian Wohlgemuth	840	Dug	20	..	...	Pleistocene till	..	Force	..	Dom	
Fu 51	8U, 17.2S, 11.0E	Ed Good	720	Dug	7	24	...	Pleistocene gravel	3	Suction	..	Com	
Fu 52	8U, 17.2S, 11.1E	Leland Rickard	720	Drl	121	6	...	do.	..	Jet	..	Dom	Flowing well. Temperature 50° F.
Fu 53	8U, 14.6S, 10.2E	Lee Kelly	1,320	Dug	15	48	...	Pleistocene till	..	Suction	..	Dom	
Fu 54	8U, 14.7S, 11.4E	Squire Gray	1,080	Drl	60	6	...	Pleistocene gravel	20	do.	..	Farm	Temperature 45° F.
Fu 55	8U, 14.5S, 11.6E	Frank Bellinger	1,050	Drl	116	6	...	do.	..	Force	3	Dom	
Fu 56	8U, 14.4S, 11.7E	Claude Smith	1,040	Dug	5	60	...	Pleistocene till	0	Suction	..	Dom	
Fu 57	8U, 14.4S, 12.0E	John Manchester	980	Dug	6	24	...	Pleistocene deposits	3	do.	..	Dom	
Fu 58	8U, 13.3S, 12.6E	Frances Putnam	1,040	Dug	20	24	...	Pleistocene till	18	..	..	Dom	
Fu 59	8U, 13.3S, 12.6E	Viola Best	1,040	Dug	20	48	...	Pleistocene gravel	7	..	..	Dom	
Fu 60	8U, 13.4S, 12.7E	Jennie Blanchard	1,040	Drl	225	6	218	..	..	Suction	1.5	Dom	Flowing well. Yield given is for flow alone. Temperature 49° F.

See footnotes at end of table.

Table 6.—Records of selected wells in Fulton County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 61	8V, 12.4S, 0.1E	John J. Kearns	1,140	Drl	65	6	...	Pleistocene gravel	19	Force	3	Dom	(b)
Fu 62	8U, 5.5S, 12.1E	M. Arnold	1,560	Dug	20	24	...	Pleistocene till	..	Pitcher	..	Dom	Well is reported to contain hydrogen sulfide.
Fu 63	8U, 4.5S, 11.6E	Ward Nixon	1,560	Drl	102	6	...	Pleistocene gravel	20	Suction	45	Com	Temperature 50° F.[a]
Fu 64	8V, 6.9S, 0.6E	Luther and Vonhoff	1,600	Drl	48	6	28	Pre-Cambrian rocks	4	Jet	..	Com	
Fu 65	8V, 7.4S, 0.7E	J. M. Shine	1,600	Drl	63	12	...	Pleistocene gravel	28	Force	15	Dom	Thirty-foot screen.
Fu 66	8V, 8.7S, 1.2E	Charles E. Templeton	1,460	Drl	60	6	...	do.	12	do.	1.5	Dom	
Fu 67	8V, 14.4S, 2.0E	R. Landreville	1,090	Drl	101	6	...	..	..	do.	..	Dom	
Fu 68	8V, 10.5S, 3.3E	Albert Peck	1,360	Drl	40	6	...	Pleistocene gravel	20	do.	3	Dom	
Fu 69	8V, 11.2S, 4.0E	Edward Jacobson	1,480	Drl	40	6	34	Pre-Cambrian rocks	20	Suction	..	Dom	
Fu 70	8V, 13.8S, 3.9E	Raymond Waffle	1,250	Dug	12	48	...	Pleistocene deposits	6	Force	..	Dom	
Fu 71	8V, 15.7S, 4.5E	Everett Quackenbush	820	Dug	13	24	7	Canajoharie shale	8	do.	..	Dom	
Fu 72	8V, 16.3S, 5.4E	R. Bronk	770	Dug	16	24	...	Pleistocene till	10	Suction	..	Dom	
Fu 73	9V, 0.6S, 6.1E	P. E. Mraz	680	Drl	84	6	...	Canajoharie shale	20	do.	..	Farm	Well is reported to contain hydrogen sulfide.
Fu 74	8V, 15.0S, 6.0E	A. Moyniham	830	Drl	137	6	93	do.	36	Force	2	Dom	
Fu 75	8V, 13.6S, 5.9E	School District 18, Meco	860	Drl	150	6	...	Pleistocene gravel	..	do.	..	Dom	(a)
Fu 76	8V, 13.3S, 5.6E	M. A. Benjamin	960	Drl	55	6	...	do.	28	Jet	1	Dom	
Fu 77	8V, 13.2S, 5.4E	H. Ruoff	980	Drl	40	6	...	do.	10	..	2	Dom	
Fu 78	8V, 12.4S, 6.4E	C. Foland	1,070	Drl	65	6	...	do.	30	Force	..	Dom	
Fu 79	8V, 12.0S, 6.1E	School District 17, Johnstown	1,150	Drl	190	6	...	do.	75	do.	4	Dom	(a)
Fu 80	8V, 8.8S, 6.6E	George Hunt	1,470	Drl	102	6	50	Pre-Cambrian rocks	15	Jet	20	Dom	Temperature 49° F.[a]
Fu 81	8V, 7.7S, 6.6E	Elizabeth Holoway	1,600	Drl	45	6	0	do.	2	Force	15	Dom	Temperature 47° F.[a]
Fu 82	8V, 7.0S, 5.3E	Robinson and Ernst Hotel	1,375	Drl	45	..	...	Pleistocene gravel	24	Jet	..	Com	
Fu 83	8V, 5.3S, 6.5E	Lindsley Corners School	1,470	Dug	11	36	...	Pleistocene till	6	Force	..	Dom	
Fu 84	8V, 5.4S, 6.6E	Selia Wemple	1,470	Dug	19	48	...	do.	19	Bucket	..	Dom	
Fu 85	8V, 12.7S, 8.7E	Earl Luizzi	875	Drl	68	6	51	Canajoharie shale	20	Jet	20	Dom	Well is reported to contain hydrogen sulfide.
Fu 86	8V, 13.0S, 8.3E	Glove City Dairy	860	Drv	20	2	...	Pleistocene gravel	19	Suction	..	Ind	Temperature 48° F.
Fu 87	8V, 13.0S, 8.3E	do.	860	Drv	20	2	...	do.	19	do.	..	Ind	Do.
Fu 88	8V, 14.3S, 7.7E	Liberty Dressing Co.	770	Drl	365	6	...	Canajoharie shale	..	None	..	Ind	This well is not used at present. Temperature 50° F.
Fu 89	8V, 15.0S, 7.5E	Modern Tanning Co.	760	Dug	14	14' sq.	...	Recent alluvium	11	Rotary	..	Ind	Temperature 58° F. Not used at present.[a]

See footnotes at end of table.

Table 6.—Records of selected wells in Fulton County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 90	8V, 14.4S, 8.5E	Fred Tasker	940	Drl	265	6	...	Pleistocene till	..	None	0	Dom	Well filled in.[a]
Fu 91	8V, 14.1S, 9.4E	Asa Wilder	910	Drl	312	6	179	Canajoharie shale	100	Force	3	Dom	Well supplies four families.
Fu 92	8V, 13.0S, 9.3E	E. H. Harrington	920	Drl	135	6	47	do.	51	Jet	2.5	Dom	
Fu 93	8V, 11.7S, 10.1E	A. J. Beard	850	Drl	116	6	16	do.	..	do.	3	Dom	
Fu 94	8V, 13.0S, 10.8E	Patrick Crocetta	850	Drl	225	6	50	do.	10	do.	15.2	Farm	Well is reported to contain hydrogen sulfide. Temperature 58° F.
Fu 95	8V, 13.9S, 10.8E	School District, Mayfield	860	Drv	15	1.25	...	Pleistocene gravel	..	Suction	3	Dom	Temperature 45° F.
Fu 96	8V, 13.9S, 10.8E	John Arnott	860	Drv	17	1.25	...	Pleistocene sand	8	do.	..	Dom	
Fu 97	8V, 16.2S, 8.5E	Lauren Ruback	800	Drl	108	6	95	Canajoharie shale	6	do.	3.5	Farm	
Fu 98	8V, 14.4S, 12.6E	Burton Argotsinger	820	Drl	25	36	13	do.	8	Force	..	Dom	Temperature 48° F.[a]
Fu 99	8V, 11.1S, 10.9E	Ronald Burgees	830	Drl	122	8	18	do.	6	do.	5.5	Farm	
Fu 100	8V, 10.5S, 11.3E	Clayton Browser	820	Drl	101	6	30	do.	35	Jet	1.5	Dom	
Fu 101	8V, 10.5S, 11.7E	Mayfield Water Works	775	Dug	26	..	...	Pleistocene gravel	9	Triplex Suction	100	PWS	Well is partly fed by three springs. Temperature 49° F. Slight drawdown is reported when pumped at 60 gallons per minute.[a]
Fu 102	8V, 9.6S, 12.1E	Joe Check	870	Drl	105	6	14	Canajoharie shale	30	Force	3.5	Com	
Fu 103	8V, 8.1S, 10.8E	Edwin Templeton	1,280	Dug	18	48	...	Pleistocene till	10	Bucket	..	Dom	
Fu 104	8V, 8.0S, 10.9E	Cora Rastrick	1,260	Dug	26	36	...	Pleistocene gravel	21	do.	..	Dom	Temperature 48° F.
Fu 105	8V, 8.1S, 11.1E	Norman Gallup	1,250	Dug	20	36	...	do.	9	Pitcher	..	Dom	
Fu 106	8V, 8.0S, 11.2E	Jackson Summit School	1,250	Dug	40	36	...	Pleistocene till	..	Force	..	Dom	
Fu 107	8W, 3.9S, 1.5E	Palmer Edwards	860	Dug	12	36	...	do.	6	do.	..	Dom	
Fu 108	8W, 4.0S, 1.4E	Edward Shaw	840	Dug	38	..	...	do.	33	do..	..	Dom	
Fu 109	8W, 4.9S, 1.1E.	Edith Stewart	880	Dug	19	20	...	do.	14	do.	..	Dom	
Fu 110	8W, 5.1S, 1.1E	Cyrus Warner	890	Drl	65	6	...	Little Falls Dolomite	..	do.	3	Dom	
Fu 111	8W, 5.3S, 1.0E	do.	900	Dug	40	48	...	Pleistocene till	34	do.	..	Dom	
Fu 112	8W, 6.5S, 1.5E	Burdette Warner	785	Drl	41	6	...	do.	6	Suction	7.5	Dom	
Fu 113	8W, 6.8S, 1.4E	Esther Ferency	790	Drl	73	6	...	Pleistocene sand	..	do.	..	Dom	
Fu 114	8W, 7.7S, 0.6E	Earl Zea	820	Drl	109	6	82	Pre-Cambrian rocks	32	Jet	2.5	Dom	Temperature 49° F.[a]
Fu 115	8W, 7.8S, 0.6E	Donald Van Nostrand	790	Drl	77	6	...	Pleistocene sand	18	Force	..	Dom	(b)
Fu 116	8W, 7.8S, 0.7E	A. Wojeski	790	Drl	99	6	...	do.	10	Jet	4	Dom	
Fu 117	8W, 8.6S, 0.7E	V. J. Warner	840	Drl	130	6	13	Little Falls dolomite	13	do.	6	Farm	
Fu 118	8W, 8.9S, 0.7E	Lauren Sart	780	Drl	134	6	114	do.	75	Force	5	Dom	(a)
Fu 119	8W, 13.1S, 1.1E	Robert Lens	860	Drl	140	6	92	Canajoharie shale	30	do.	1.5	Farm	Well is reported to contain hydrogen sulfide.

See footnotes at end of table.

Table 6.—Records of selected wells in Fulton County, New York (Continued)

Well number.	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 120	8W, 14.1S, 0.3E	E. L. Coons	820	Drl	65	6	...	Pleistocene gravel	..	Jet	..	Farm	
Fu 121	8W, 13.9S, 1.6E	Chris Hults	780	Drl	68	6	30	Little Falls dolomite	4	Suction	30	Dom	Reported drawdown is 31 feet when pumped at 30 gallons per minute.
Fu 122	8W, 14.0S, 1.6E	Henry Lingerfelter	790	Drl	65	6	11	Glens Falls limestone	..	..	6	Dom	Temperature 43° F.[a]
Fu 123	8W, 16.6S, 1.6E	Barnoski Brothers	950	Drl	223	6	...	Pleistocene gravel	100	Force	6	Dom	[b]
Fu 124	8W, 16.8S, 1.5E	L. Pickrell	950	Drl	265	6	226	Canajoharie shale	..	do.	..	Dom	
Fu 125	9W, 1.1S, 2.8E	John Wellinger	770	Drl	182	6	...	Pleistocene gravel	6	Suction	20	Dom	[b]
Fu 126	9W, 1.0S, 3.0E	S. Brown	770	Drl	147	6	...	do.	3	do.	35	Dom	Reported drawdown is 27 feet when pumped at 35 gallons per minute.
Fu 127	9W, 1.0S, 4.8E	Stephen Olander	790	Drl	69	6	10	Little Falls dolomite	2	Force	..	Dom	
Fu 128	8W, 16.2S, 2.8E	Youth Bible Congress	870	Drl	107	6	85	Glens Falls limestone	11	Suction	5	Dom	[b]
Fu 129	8W, 16.1S, 2.8E	Charles Hinkle	870	Drl	107	6	98	do.	15	..	..	Dom	
Fu 130	8W, 14.9S, 2.3E	Thomas Kozlowski	915	Dug	31	36	...	Pleistocene sand	..	..	..	Farm	
Fu 131	8W, 14.1S, 2.7E	Town of Broadalbin	840	Drl	81	6	...	Pleistocene gravel	12	Force	125	PWS	Reported drawdown is 15 feet when pumped at 125 gallons per minute.[a]
Fu 132	8W, 13.5S, 2.3E	Jacob Zuckerwar	800	Drl	96	6	...	Pleistocene deposits	18	..	2	Dom	[b]
Fu 133	8W, 12.2S, 2.6E	R. W. Brauns	840	Dug	10	36	...	Pleistocene till	2	Suction	..	Farm	
Fu 134	8W, 11.4S, 2.8E	N. H. Lasher	820	Dug	18	36	...	do.	8	..	..	Dom	
Fu 135	8W, 10.6S, 3.4E	Nick Nyszczy	820	Dug	26	54	...	do.	9	Suction	..	Dom	Temperature 51° F.[a]
Fu 136	8W, 10.3S, 3.9E	Harry Minkler	780	Drl	65	6	18	Canajoharie shale	8	do.	6	Dom	Reported drawdown is 52 feet when pumped at 6 gallons per minute.
Fu 137	8W, 4.8S, 2.6E	U. S. Feldspar Corp.	820	Drl	186	8	40	Glens Falls limestone	10	None	40	Ind	Well is not used at present.
Fu 138	8W, 4.4S, 2.6E	Ferguson & Mittlstaedt	820	Drl	140	6	15	Little Falls dolomite	16	Jet	5	Com	
Fu 139	8W, 1.3S, 3.1E	William E. Hobbs	750	Drl	128	6	...	Pleistocene gravel	28	Force	13	Com	[a]
Fu 140	8W, 1.3S, 3.3E	Fred Standhardt	750	Drl	125	6	4	Pre-Cambrian rocks	13	..	1	Dom	
Fu 141	8W, 2.4S, 5.1E	M. H. Lindsey	950	Drl	62	8	3	Potsdam sandstone	30	Force	3	Farm	Temperature 50° F.[a]
Fu 142	8W, 3.0S, 5.5E	Andrew Madison	930	Dug	18	24	...	Pleistocene sand	12	do.	..	Dom	
Fu 143	8W, 3.5S, 5.9E	M. Darling	890	Dug	14	..	...	do.	10	do.	..	Dom	
Fu 144	8W, 7.2S, 6.4E	Ralph V. Hayden	790	Drl	42	6	...	Little Falls dolomite	17	..	..	Dom	
Fu 145	8W, 7.3S, 6.1E	Kathern Boice	770	Dug	10	24	...	Pleistocene gravel	6	Force	3	Dom	
Fu 146	8W, 9.7S, 4.8E	James Fyfe	800	Drl	117	6	80	Glens Falls limestone	27	do.	..	Dom	Temperature 54° F.[a]
Fu 147	8W, 10.0S, 4.5E	Joseph Pelcher	790	Drl	53	6	...	do.	8	Suction	..	Dom	
Fu 148	8W, 10.4S, 4.3E	John A. Hughes	850	Drl	67	6	44	Canajoharie shale	10	Force	12	Dom	
Fu 149	8W, 10.6S, 4.3E	C. T. Gorthey	855	Dug	17	..	...	Pleistocene till	13	do.	3	Dom	

See footnotes at end of table.

Table 6.—Records of selected wells in Fulton County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 150	8W, 11.0S, 4.6E	Emma Kunz	865	Dug	14	48	...	Pleistocene till	9	Force	..	Dom	
Fu 151	8W, 11.7S, 3.7E	William Pyristy	840	Dug	9	48	...	do.	5	Bucket	..	Dom	
Fu 152	8W, 12.8S, 3.0E	C. S. Husted	820	Drl	300	6	35	Little Falls dolomite	..	..	1.5	Dom	Flowing well. Record was obtained from U. S. Geol. Survey Water-Supply Paper 102, p. 181.
Fu 153	8W, 12.8S, 3.1E	M. K. Husted	820	Drl	301	6	165	do.	..	..	2	Dom	Do.
Fu 154	8W, 12.7S, 3.5E	J. Konikiewcz	830	Dug	26	34	...	Pleistocene till	23	Force	..	Dom	
Fu 155	8W, 12.8S, 4.6E	G. Kiriluk	830	Dug	15	42	14	Amsterdam limestone	13	do.	3	Dom	Temperature 48° F.[a]
Fu 156	8W, 12.1S, 4.4E	Charles Beletsky	910	Drl	88	6	...	..	..	do.	..	Dom	
Fu 157	8W, 11.5S, 5.3E	Wilbur Chase	885	Drl	91	6	85	Little Falls dolomite	..	do.	6	Dom	(b)
Fu 158	8W, 11.1S, 6.3E	Martha Probl	920	Dug	14	36	...	Pleistocene gravel	10	Bucket	..	Dom	
Fu 159	8W, 11.0S, 6.9E	Alva Fosmire	940	Drl	40	6	...	do.	7	..	3.5	Dom	
Fu 160	8W, 13.1S, 6.5E	John Salak	1,020	Drl	136	6	...	do.	36	Jet	8	Farm	
Fu 161	8W, 13.3S, 5.9E	George G. Wood	970	Drl	100	6	75	Little Falls dolomite	..	..	1.5	Dom	Temperature 54° F.[a]
Fu 162	8W, 13.5S, 3.7E	M. Opalka	850	Drl	124	6	100	do.	25	Force	4.5	Dom	Reported drawdown is 6 feet when pumped at 4.5 gallons per minute. Temperature 50° F.[a]
Fu 163	8W, 15.8S, 3.9E	A. S. Blood	887	Dug	18	36	...	Pleistocene sand	12	Suction	..	Farm	
Fu 164	8W, 15.4S, 4.7E	Orlie Philips	900	Dug	22	48	...	do.	11	Force	..	Dom	
Fu 165	8W, 14.1S, 4.9E	Lawrence Opalka	950	Dug	35	48	...	Pleistocene till	17	do.	..	Dom	(b)
Fu 166	8W, 14.4S, 5.4E	Cecil Loucks	950	Dug	...	48	...	do.	11	do.	..	Farm	
Fu 167	8W, 14.6S, 5.6E	Stephen Czupyk	980	Dug	35	48	...	Pleistocene sand	28	do.	..	Dom	
Fu 168	8W, 15.7S, 6.0E	John Batoski	880	Dug	20	48	...	do.	..	Suction	..	Dom	
Fu 169	8W, 16.7S, 7.6E	Charles Jackson	820	Drl	83	6	5	Theresa dolomite	15	Force	..	Farm	
Fu 170	8W, 16.8S, 7.5E	School District No. 6, Perth	870	Drl	50	6	5	do.	..	Force	..	Dom	Temperature 48° F.[a]
Fu 171	8W, 17.2S, 7.5E	Alice Harris	840	Drl	45	6	10	Little Falls dolomite	16	Suction	40	Dom	
Fu 172	8V, 14.2S, 9.1E	Robert Winchell	900	Drl	141	6	125	Canajoharie shale	44	Jet	3	Farm	(b)
Fu 173	8V, 13.9S, 9.0E	Laten Conklin	870	Drl	233	6	78	do.	..	..	..	Dom	
Fu 174	8V, 14.0S, 8.9E	School District No. 5, Johnstown	890	Drl	165	..	120	do.	..	Force	..	Dom	Water from well is available to general public.
Fu 175	8V, 13.1S, 9.1E	W. Lesperence	890	Drl	205	6	100	do.	35	Jet	4	Dom	
Fu 176	8V, 14.6S, 9.0E	Hyde Park Real Estate Co.	880	Drl	150	6	...	Pleistocene gravel	60	Force	12	Dom	Well is used by several households.
Fu 177	8V, 14.5S, 8.8E	Perry Bissell	860	Drl	117	6	...	do.	..	None	16	Dom	New well. Pump is not yet installed.
Fu 178	8V, 14.1S, 10.0E	C. A. Sherman	880	Drv	53	2.5	...	Plesitocene deposits	..	Suction	..	Dom	Well is screened.

See footnotes at end of table.

Table 6.—Records of selected wells in Fulton County, New York (Concluded)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Use	Remarks
Fu 179	8V, 14.6S, 10.4E	Lester Coon	940	Drl	135	6	128	Canajoharie shale	113	Force	..	Dom	[b]
Fu 180	8V, 14.1S, 9.6E	Chester Weaver	920	Drl	175	6	166	do.	85	do.	..	Dom	Well is reported to contain hydrogen sulfide.
Fu 181	8V, 14.2S, 9.1E	Walter Scott	900	Drl	145	6	...	Pleistocene gravel	..	Force	4	Dom	
Fu 182	8V, 14.3S, 9.3E	Stanley Combs	900	Drl	305	6	185	Canajoharie shale	94	do.	0.6	Farm	
Fu 183	8V, 14.2S, 6.6E	John Groburd	880	Drl	160	6	150	do.	..	do.	..	Dom	[b]
Fu 184	8V, 14.2S, 5.9E	A. R. Johnson	900	Drl	75	6	...	Pleistocene gravel	45	do.	..	Dom	
Fu 185	8V, 15.6S, 5.4E	David Ovitt	820	Drl	110	6	43	Canajoharie shale	30	do.	..	Dom	
Fu 186	8V, 16.1S, 4.9E	Harold Smith	820	Drl	80	6	...	do.	..	Suction	..	Dom	Flowing well during wet season.
Fu 187	8V, 15.2S, 4.6E	J. Campbell	860	Drl	67	6	67	Pleistocene deposits	3	Force	..	Dom	Well is not in use at present.
Fu 188	8V, 14.4S, 6.2E	Benton Nellis	880	Drl	163	6	139	Canajoharie shale	62	Jet	..	Dom	Well is reported to contain hydrogen sulfide.
Fu 189	8V, 15.7S, 3.8E	William J. Doe	830	Drl	48	6	...	Pleistocene deposits	6	..	40	Dom	
Fu 190	8V, 17.2S, 5.8E	Clarence Snyder	680	Drl	37	6	...	Pleistocene gravel	..	Suction	..	Dom	
Fu 191	8V, 17.3S, 5.6E	Rudolph Gunsel	680	Drl	99	6	20	Canajoharie shale	1	do.	..	Dom	
Fu 192	9V, 0.6S, 8.5E	James C. Collyer	800	Drl	40	6	...	Pleistocene deposits	2	Force	8	Dom	Temperature 48° F.
Fu 193	9V, 0.8S, 8.6E	Albany Bush School	800	Drl	160	6	...	..	..	..	..	Dom	
Fu 194	9V, 0.8S, 8.7E	Nilsen Brothers	800	Drl	60	6	...	Pleistocene gravel	10	Jet	..	Dom	
Fu 195	9V, 0.8S, 9.5E	Ralph Leslie	760	Drl	118	8	4	Canajoharie shale	50	do.	20	Dom	Well is reported to contain hydrogen sulfide.
Fu 196	9V, 0.7S, 10.3E	A. Hichens	760	Drl	109	6	24	Glens Falls limestone	22	do.	22	Farm	Do.
Fu 197	9V, 0.2S, 9.9E	H. Petraske	820	Drl	170	6	92	Canajoharie shale	15	do.	22	Farm	
Fu 198	8V, 16.3S, 8.7E	Dean Suntus	800	Drl	122	6	63	do.	..	..	3	Farm	Temperature 49° F.

[a] For chemical analysis see table 4.
[b] For drilling log see table 5.

Table 7.—Reports dealing with ground-water conditions in New York published by the New York State Water Power and Control Commission as a result of work by the State, and the U. S. Geological Survey and various county and municipal agencies

GW Bulletin	Title	Author(s)	Year published
1	Withdrawal of ground water on Long Island, N. Y.	Thompson, D. G. and Leggette, R. M.	1936
2	Engineering report on the water supplies of Long Island.	Suter, Russell	1937
3	Record of wells in Kings County, N. Y.	Leggette, R. M. and others	1937
4	Record of wells in Suffolk County, N. Y.	Leggette, R. M. and others	1938
5	Record of wells in Nassau County, N. Y.	Leggette, R. M. and others	1938
6	Record of wells in Queens County, N. Y.	Leggette, R. M. and others	1938
7	Report on the geology and hydrology of Kings and Queens Counties, Long Island.	Sanford, Homer	1938
8	Record of wells in Kings County, N. Y.	Leggette, R. M. and Brashears, M. L., Jr.	1944
9	Record of wells in Suffolk County, N. Y., supplement I.	Roberts, C. M. and Brashears, M. L., Jr.	1945
10	Record of wells in Nassau County, N. Y., supplement I.	Roberts, C. M. and Brashears, M. L., Jr.	1946
11	Record of wells in Queens County, N. Y., supplement I.	Roberts, C. M. and Jaster, Marion C.	1947
12	The water table in the western and central parts of Long Island, N. Y.	Jacob, C. E.	1945
13	The configuration of the rock floor in western Long Island, N. Y.	De Laguna, Wallace and Brashears, M. L., Jr.	1948
14	Correlation of ground-water levels and precipitation on Long Island, N. Y.	Jacob, C. E.	1945
15	Progress report on ground-water resources of the southwestern part of Broome County, N. Y.	Brown, R. H. and Ferris, J. G.	1946
16	Progress report on ground-water conditions in the Cortland quadrangle, N. Y.	Asselstine, E. S.	1946
17	Geologic correlation of logs of wells in Kings County, N. Y.	De Laguna, Wallace	1948
18	Mapping of geologic formations and aquifers of Long Island, N. Y.	Suter, Russell; De Laguna, Wallace; and Perlmutter, N. M.	1950
19	Geologic atlas of Long Island.	.....	1950
20	The ground-water resources of Albany County, N. Y.	Arnow, Theodore	1949
21	The ground-water resources of Rensselaer County, N. Y.	Cushman, R. V.	1950
22	The ground-water resources of Schoharie County, N. Y.	Berdan, Jean M.	1950
23	The ground-water resources of Montgomery County, N. Y.	Jeffords, R. M.	1950

INDEX

Abstract, 1
Acknowledgments, 2
Adirondack Mountains, 4
Alluvial deposits, 7, 17, 20, 28
Amsterdam limestone, 6, 17, 19, 28
Artesian conditions, 18

Batchellerville fault, 4
Bicarbonate in water, 27
Black River beds, 6
Broadalbin, water supply of, 23
Buried valley, 8

Cambrian formations, 7, 16, 19
Cambrian period, 6
Canajoharie shale, 6, 7, 17, 19, 28
Chlorides in water, 24
Climate, 5

Dissolved solids, 24
Drainage, 4
Drilled wells, 20
Drawdown, 21
Drumlins, 17
Dug wells, 20

Electrical resistivity profiles, 8

Faults, 4, 6

Geography, 4
Geologic formations
  Alluvial deposits, 7, 17, 20, 28
  Amsterdam limestone, 6, 7, 17, 19, 28
  Black River beds, 6
  Canajoharie shale, 6, 7, 17, 19, 28
  Glacial deposits, 7, 8, 17, 19, 28
  Glens Falls limestone, 6, 7, 17, 19, 28
  Ground moraine, 17
  Little Falls dolomite, 6, 7, 16, 19, 28
  Lowville limestone, 6, 7, 17, 19, 28
  Outwash, 17, 20
  Potsdam sandstone, 6, 7, 16, 19, 28
  Quaternary deposits, 7, 17, 19
  Theresa dolomite, 6, 7, 16, 19, 28
  Tribes Hill limestone, 6, 7, 16
Geologic history, 6
Glacial deposits, 7, 8, 17, 19, 28
Glaciation, 8
Glens Falls limestone, 6, 7, 17, 19, 28
Gloversville, water supply of, 23
Grenville series, 6, 7, 16
Ground moraine, 8, 17
Ground water, 18
  bulletins for New York State, 40
  occurrence of, 18
  quality in relation to rock type, 28
  quality of, 24
  recovery of, 20
  source of, 18
  summary of conditions, 29
  temperature, 27
  utilization, 23

Hardness, 27
Hudson River, 4
Hydraulic permeability, 18
Hydrogen-ion concentration, 27

Igneous rocks, 6, 7, 16
Introduction, 2
Iron in water, 24

Johnstown, water supply of, 23

Kame terraces, 17
Kames, 17
Kecks Center, water supply of, 23

Lakes, 5
Lake deposits, 17
Little Falls dolomite, 6, 7, 16, 19, 28
Location of area, 4
Locations of wells and springs, 2
Lowville limestone, 6, 7, 16, 19, 28

Manganese in water, 24
Mayfield, water supply of, 23
Mohawk fault series, 4, 6
Mohawk River, 4
Mohawk Valley, 4

Northville, water supply of, 23
Noses fault, 4

Open end casings, 21
Ordovician formations, 7, 16, 19
Outwash deposits, 17, 20

Paleozoic sediments, 6, 7
Perforated casings, 21
pH value, 27
Population, 4
Porosity, 18
Potsdam sandstone, 6, 7, 16, 19, 28
Pre-Cambrian rocks, 6, 7, 16, 18, 28
Precipitation, 5, 18

Quadrangles, 6
Quality in relation to rock type, 28
Quality of water, 24
Quaternary deposits, 7, 17, 19

Recovery of water, 20
References, 30
Rock formations, 16

Sacandaga Reservoir, 4
Sacandaga River, 4, 8
Sacandaga, water supply of, 23
Saratoga fault, 6
Saratoga Springs, 6
Screens, 21
Seismic profiles, 8
Specific capacity, 21
Specific yield, 18
Springs, 21
Stream-gaging stations, 4
Sulfate in water, 27
Summary of ground-water conditions, 29

Temperature, 5, 27
Theresa dolomite, 6, 7, 16, 19, 28
Till, 7, 8, 17, 19
Topographic maps, 6
Topography, 4
Tribes Hill limestone, 6, 7, 16

Utilization of water, 23
  commercial, 23
  domestic, 23
  industrial, 23
  public, 23
  school, 23

Watershed divide, 4
Water supply
  Broadalbin, 23
  Johnstown, 23
  Kecks Center, 23
  Mayfield, 23
  Northville, 23
  Sacandaga, 23
Water table, 18
Well records, 33
Well logs, 31
Well-numbering, 2
Wells
  drilled, 20
  driven, 20
  dug, 20
Wells flowing, 18